# RIVER IRWELL

North Manchester Restoration Project

## Restoration and Enhancement

For:

The Environment Agency

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# Introduction

The RRC were asked by the Environment Agency to visit the River Irwell between Rawtenstall and Salford, Greater Manchester, and the Kirklees Brook between Hawkshaw and its confluence with the Irwell, and comment on the potential for restoration and enhancement. Present at the site on 20th to 22nd January 2009 were Gary Morris (EA), Fiona Percival (EA), Jenny Mant (RRC) and Abi Pryce (RRC). A second visit to the Kirklees Brook and the middle sections of the Irwell was made on 19th and 20th March 2009. This report has been produced to advise and comment on possibilities for restoration and enhancement along the course of the Irwell, and to identify further information that may be required to take the project to the next stage.

The report is structured on a map-by-map basis as outlined in Appendix A, and is compiled from a short rapid walkover survey and an overview of secondary information. Its primary focus is to flag up opportunities that may be feasible to implement through future development and flood risk management, in the context of requirements of the Water Framework Directive (WFD) to improve river continuity, enhance biodiversity features and reconnect people to rivers through stakeholder engagement.

The RRC undertakes this work through its Memorandum of Agreement (MoA) with The Environment Agency.

# Contents

# 1 Background

The River Irwell rises at Deerplay Moor, Cliviger (Lancashire) and runs south through Bacup, Rawtenstall, Ramsbottom, Bury and Kearsley before joining the Manchester Ship Canal in Salford, south of Irlam. Major tributaries include the Roch, the Croal, the Irk and the Medlock. This phase of the RRC's work (Phase 1) concentrated on the Irwell between Rawtenstall and Salford, and the Kirklees Brook between Hawkshaw and its confluence with the Irwell. The Croal and the Roch will be the subject of a similar study in the future (Phases 2 and 3).

The upper region is largely rural and fairly steep whereas the lower region is mostly urban and less steep. More than 30% of the catchment is urban including Manchester, Salford and Oldham in the south and Bury, Bolton and Rochdale in the centre (Environment Agency, 2008). The river has a long history of modification dating back to the industrial revolution, which includes walling, deepening, re-alignment, culverting, widening, dredging, straightening, and the construction of weirs. Many of these structures are now in poor condition and are crumbling or collapsing into the river channel, contributing to the supply of coarse, but unnatural, bedload material. Artificial structures such as weirs and culverts can also obstruct flow and result in accumulations of sediment within the channel, which in the past has been removed by channel dredging at some locations. Many of these structures were constructed as part of historical industrialisation of the area, and where they have collapsed there is evidence that the river has begun to naturally adjust, often with riffle features occurring downstream. In most cases there was little or no evidence (from the walkover survey) of any negative impacts in terms of additional fine sediment accumulation downstream.

## *1.1 Existing Reports and Information*

### 1.1.1 Upper Irwell Fluvial audit

Babtie, Root and Brown were commissioned by the Environment Agency in 2004 to undertake a fluvial audit of the Upper River Irwell from the source in Bacup to its confluence with the River Roch. The survey extended to four major tributaries including Whitewell Brook, Limy Water, the River Ogden and Kirklees Brook. At the time of the survey (2004) sediment was regularly dredged from the channel to reduce flood risk at vulnerable locations. As gravel extraction damages the ecology (fish and benthic invertebrates), reduces habitat diversity and contributes further to channel instability, the audit aimed to recommend a more sustainable approach to managing sedimentation.

The report provides a baseline dataset segmented on the basis of changes in geomorphology and physical processes or features. It concludes that in-channel sedimentation is a major issue in the Upper Irwell catchment due to sediment supply from the headwaters; the heavily modified channel, which is over-wide and over-deep in many reaches; and the additional unnatural sediment supply from collapsing walls and other structures. It recommends that sediment transfer within the system should be improved along with other measures such as targeting high supply areas of unnatural sediment from collapsed walls and encouraging inundation of the floodplain. Although it may be necessary to continue targeted dredging in the short term, the report concludes that it should be possible to reduce and even completely discontinue this practice in the future.

### 1.1.2 Upper Irwell Gravel Management Plan

The Upper Irwell Gravel Management Plan builds on the Fluvial Audit and was undertaken by Jacobs Babtie in 2005/2006. It covers the upper catchment of the Irwell from its source to the confluence with the River Roch and provides a catchment scale assessment of the link between geomorphological processes and flood risk, providing alternative suggestions for flood risk management. It identifies current causes of flooding including constriction due to culverting and bridges, low channel capacity resulting from sedimentation, poor condition of existing flood defences such as walls, reduced channel capacity caused by tipped material, and development on the floodplain.

A number of general catchment-scale policies are recommended, such as repair or removal of unstable walls, structures or defences, reduction of waste tipping, and preservation of natural geomorphological processes such as bank erosion. Site specific actions such as vegetation management, bank protection and wall repairs were also recommended.

### 1.1.3 River Irwell Catchment Flood Management Plan

The River Irwell Catchment Flood Management Plan (CFMP) covers an area of 715 $km^2$ from the moors above Bacup in the north to the centre of Manchester in the south. Watercourses in the upper reaches of the catchment are characterised by steep narrow valleys, which results in rapid run off and makes it difficult to provide adequate flood warnings. Floodplains in the catchment are generally small, which may limit possibilities for viable natural flood storage in these areas.

Impermeable Till/Boulder Clay makes up a large proportion of the catchment. This increases the amount of standing water and rapid surface run-off into rivers and therefore increases the risk of flooding. There are smaller areas of glacial sands/gravels and sandstones/mudstones in the Irk and Medlock catchments, which will limit runoff due to the higher infiltration of surface water into the aquifer (Environment Agency, 2008).

Apart from the main flood risk area on the floodplain in Salford, potential for flooding has been identified around Rochdale, Littleborough, Ramsbottom and Radcliffe as well as at a number of smaller sites in the Rossendale Valley. Flood risk on the Irwell is increased by a number of factors including channel modification (channelization and culvert construction from mill buildings), flood walls, embankments, channel walls and culverts. Falling masonry can block the channel or even collapse into the channel completely. The Environment Agency has estimated that 7% of the raised defences are in poor condition and 50% were not constructed specifically for flood defence. There are several thousand of these defences in the Irwell catchment, however the majority are on private land and are not owned by the Environment Agency.

Flood risk maintenance operations in the Irwell catchment include regular inspection and clearance of debris screens and culverts, particularly at high risk areas. Channels are dredged where siltation is a particular problem, in order to increase channel capacity. However, removal of sediment/gravel by dredging could in future go against WFD principles, owing to its effect on morphological diversity.

The catchment has been divided into 21 Policy Units, each of which has a defined preferred policy for managing flood risk.

### 1.1.4 The Northern Manchester Catchment Abstraction Management Strategy

The River Irwell is the major river in this catchment and is included within Water Resource Management Unit 1 – River Irwell. The water resource availability status for this unit is 'Water Available' at low flows. The status of the Irwell Valley Aquifer Groundwater Management Unit is 'Over-licensed'.

### 1.1.5 Environment Agency GQA data

Environment Agency General Quality Assessment (GQA) data are available at a number of locations along the length of the Irwell and at one location on the Kirklees Brook. In the upper reaches of the Irwell, the water quality is generally good, with the stretches between Deerplay and the confluence with the Roch (to the east of Radcliffe) being graded as 'A' for Chemistry in 2007. Biology is ungraded in the upstream reaches until the stretch between Chest Wheel Bridge and the confluence with the Roch, which was graded as 'D'. In the lower reaches between the Roch confluence and Salford University, the water quality is significantly worse, with Chemistry graded as 'E' and Biology as 'D'.

On the Kirklees Brook between Olive Paper Mill and the confluence with the Irwell, Chemistry was graded as 'A' in 2007. Biology for this stretch was ungraded.

### 1.1.6 Environment Agency NFCDD data

The Environment Agency National Flood and Coastal Defence Database (NFCDD) was queried to produce a list of flood defence structures on the Irwell and Kirklees Brook. This included all types of structures such as: outfalls; sluices; weirs; footbridges and road bridges; pipe crossings; culverts and channel linings; embankments and flood walls; as well as sections of natural channel. The exact location and a short description are given for each structure as well as information on the maintainer (private or Environment Agency).

## *1.2 Future Opportunities and Schemes*

It should be noted that there are various flood schemes, bank repairs and developments proposed for this area. In each case it would be beneficial to aim to establish whether the options suggested in this report could be included within other works. Whilst opportunities in this report are not thought to intensify flooding where there is perceived high risk, nonetheless, any suggestions would need to undergo appropriate levels of flood risk modelling in all cases.

Whilst there are likely to be many other opportunities to improve the watercourse for ecological and morphological gain, some key schemes have been highlighted as follows:

- The Irwell Vale flood risk management scheme which is programmed for project appraisal in 2010/11, with construction estimated to be completed during 2012/2013.
- The Ramsbottom flood risk management scheme which is programmed for project appraisal in 2010/11, with construction estimated to be completed during 2012/2013.

- Salford sheet piling repairs which is currently proposed for 2010/11 along a 9km section where bank erosion is deemed a risk and an asset inspection identified there structures as nearing the end of their serviceable life.
- Littleton Road Basin proposal for additional car parking close to the current location of bunds where recommendations have been made to consider an option to set back the nearby flood defence and re-profile the current river banks.

# 2 Site Visit Notes and Recommendations

Section maps referred to below can be found in Appendix A and a full photographic record of the survey can be found in Appendix B.

***In addition, a summary table with the upstream grid reference of each potential opportunity is presented in section 4. This includes recommendations about questions that need to answered, a summary of options and a simple 'high, medium or low' cost-benefit assessment.***

## *2.1 Map 1 – Rawtenstall SD80522227*

*Visited Tuesday 20th January 2009 (pm) and Wednesday 21st January 2009 (am)*

The assessment of this stretch started at New Hall Hey, at the footpath off New Hall Hey Road, along the right bank. A high embankment is visible on the left bank at the first bend in the river, between New Hall Hey Road and Holme Lane (Photos 3 and 4). Whilst this severely reduces connectivity to the floodplain at this location, the amount of material here, together with the railway line behind, means that any floodplain reconnection at this point is unlikely to be feasible unless it was completed as part of a much larger development scheme for the whole area. Downstream is a long stone flood wall along the majority of the left bank of this stretch of river, which is a privately maintained structure. The wall is crumbling or has collapsed into the river in some places (Photo 7) and could be improved with some basic maintenance, although in some cases it might be preferable to allow the walls to disintegrate provided that the channel does not become blocked. From a sort walkover survey there appears to be no flood risk issue along this section and therefore, it is assumed that the walls are a legacy of past industrialisation and/or agriculture use of the surrounding floodplains. It would be beneficial, from an ecological perspective, to allow more natural processes to occur at this site by allowing degradation of the wall to continue but this should be with agreement from the land owner. Some maintenance will be needed however, in terms of some removal of large pieces of masonry should they start to cause an unacceptable blockage in the river. It is recommended that some simple monitoring is introduced through fixed point photography to assess the impact of the failure of the wall on the reach and that immediately downstream.

A privately-owned weir is present within this section (photo 5) (SD80202218), which is beginning to fail, as is the case with many of the old weir structures along this watercourse. Whilst this may not be causing a major blockage to fish passage, it is interrupting the flow of natural processes and river flow continuity nonetheless. It would be worth considering removing this weir. However, in places where weirs have been naturally washed out along this watercourse, it appears that the river has freely adjusted and there is no evidence of major negative impacts. Given the location of this structure a 'do nothing' approach could be a valid option. Just downstream of this weir, the Langwood Brook then joins the Irwell at Holme Lane, through a culvert under Holme Lane (Photo 8).

Just upstream of the A56/A682 is a second weir which is clearly impeding continuity in this section. Whilst the weir is an old structure, it is presumed that the main road crossing location was made coincidental with it to afford stability to the bed and ensure that the associated road bridge culvert remains clear of debris and sediment. The weir appears to be in good condition but provides a major impediment to flow

continuity and fish passage. To remove this weir would require a detailed assessment of stability of the reach and flood risk issues. Space under the road is limited so there is no opportunity to install a bypass channel. Installing a fish ladder may be the only solution at this point.

Just downstream of Blackburn Road there is an area of open derelict land which could afford some potential for enhancement in terms of a riparian area for the benefit of wildlife and public amenity. It is recognised that this section houses a football pitch and buildings in close proximity to the river. Although opportunities may be limited to a narrow river corridor, it would be worth considering introducing some offline ponds and scrapes along the edge of the river.

The river then passes underneath the East Lancashire Railway. There are two outfalls from the sewage works in the right bank (Photo 13 on Map 1 and Photo 8 on Map 2). Again, the majority of the river bank is walled in this area and the structures are privately owned.

**Summary of recommendations**

- Allow for natural collapsing of stone walls where appropriate.
- Remove or allow natural collapse of small weir downstream of Bens Cen.
- Investigate the potential for creating some ponds/scrapes within the derelict land downstream of Blackburn Road, along a small riparian strip.
- Remove weir upstream of Holme Lane to improve downstream continuity.
- Improve fish passage at weir close to A56.

## *2.2 Map 2 – Edenfield SD79342039*

*Visited Wednesday 21st January 2009 (am)*

Flood walls are present along the majority of this stretch. Many of these are crumbling and collapsing into the river, particularly on the bend near Strongstry, where some of the walls are Environment Agency owned (Photos 19 and 20). Others are privately maintained flood walls and banks that protect pockets of housing close to the river (e.g. at Aitken Street and Lumb Bridge (Photos 8 and 9)). In areas such as these, potential to remove or alter the flood defence structures may be limited. However, the area at Strongstry (SD79281889) is part of a proposed Flood Alleviation assessment Scheme. The Upper Irwell Gravel Management Plan noted that this section is perceived to have inadequate channel capacity. This has resulted in dredging of the reach, with subsequent spoil heaps reducing the opportunity for floodplain connectivity and thereby increasing flood risk downstream. In addition, the intermittent dredging has had a negative impact on riverine habitats. Setting back flood bunds to allow more frequent inundation of the surrounding floodplain would be beneficial for habitat creation (especially if designed with low scrapes in the floodplain to create semi-permanent wetter areas, floodplain meadow and wet woodland areas), whilst also potentially reducing flood risk and the need to dredge this section of the river. Currently, there very few trees growing on the banks and the ground is very open (Photo 23). Planting of native trees would help to provide shading and may reduce nutrient inputs to the river as well as providing habitat for terrestrial animals. To understand what is the appropriate native riparian vegetation for the Irwell, more naturally vegetated reaches of the river should be visited (e.g. at Ringley, Clifton Country Park or Forest Bank).

There are some relatively small weirs at Aitken Street (Photo 6) and just upstream of Lumb Bridge (Photo 11), both privately maintained, which again are unlikely to represent an obstacle to fish. However, removal of these weirs would give the river a more natural appearance and reduce backwater impacts in this relatively low gradient section, provided their removal has no negative impact on nearby road bridge structural integrity. It is understood that this section has been routinely de-shoaled which will have an impact on habitat potential in this section. The regularity of de-shoaling and the rationale for when this is completed is not known; neither is there any scientific account for the benefit of the level of de-shoaling in this section. It would be beneficial to carry out some simple conveyance modelling (perhaps using Wallingford Software's Conveyance Estimation System (CES)) to evaluate the impact on water levels for different shoal heights and extent. This may help to allow for a more environmentally beneficial approach to management of this section, thus reducing the need to de-shoal and actually have a benefit in terms of increasing the sediment transport through this section once a more natural equilibrium has been reached (i.e. the river supports a low flow channel with high velocities).

Currently, much of this section is also walled. Whilst it is recognised that there is a need to stabilise the bank where it is close to properties, floodwalls, where deemed necessary, could be set back to provide more space for natural river forms and processes to occur along this section. If the weirs in this section were removed in conjunction with work completed downstream at Strongstry, this could provide beneficial opportunities to the whole reach in terms of sediment continuity and management and habitat improvements. Any changes could, in this way, be designed within the context of flood alleviation concerns. It would be worth reviewing the River Caldew project in Carlisle (http://www.environment-agency.gov.uk/research/planning/109005.aspx), where this approach has been adopted. New flood walls have been designed to integrate with footpaths, and old bank protection walls have been left in situ but it is recognised that these will degrade over time and give the watercourse and riparian zone space to recover. Even where space is extremely limited, there may be opportunities to design habitat features into walls, and where gardens abut the river, they can be landscaped to incorporate flood defences. A good example of this has been achieved in London, in Lewisham, on the river Quaggy (see Figures 1 and 2). An alternative approach would be to consider using more bio-engineering approaches, as have been completed on the River Skerne, Darlington. Here, and on the River Brent in London (Figure 3), crushed concrete, interspersed with willow poles and tied into the bank, has achieved bank stability and a more natural riparian edge. To develop such an option would require the regrading of the banks, a 'harder' stone bolder toe revetment (but well hidden below the waterline) and a commitment to some future management to cut back the vegetation every few years to ensure structural integrity of the bank protection.

**Figure 1: Flood defence wall with planting niches. River Quaggy, Lewisham**

**Figure 2: Flood defence wall set back and incorporated into gardens. River Quaggy, Lewisham.**


**Figure 3: Crushed concrete and willow pole revetment A: as installed, in 2003; and B: with vegetation establishing, in 2005. River Brent, Willesden.**

### Summary of recommendations

- Targeted maintenance of flood walls, ideally set back from the bank, or if not feasible, the use of a mixture of traditional engineering solutions and bio-engineering to create a vegetated fringe.
- Where appropriate, remove weirs through the section, and assess maintenance strategy for shoal removal.
- Remove spoil banks at Strongstry and reduce river maintenance.
- Plant native trees and riparian vegetation and create floodplain scrapes particularly in the Strongstry area.

## *2.3 Map 3 – Ramsbottom SD79161874*

*Visited Wednesday 21st January 2009 (am)*

At Chatterton there are sections of bank that are protected with old stone walling (see photo 5). In other places, as shown in (Photo 2), the walls are crumbling. Where this is occurring there are clearly signs of bank re-grading. How much of this is related to natural river processes and how much to sheep grazing is difficult to ascertain. However, it is recommended that these walls are left to deteriorate and for the river to work with the natural processes. Depending on the levels of sheep stocking throughout the year (this is not known) it may be necessary to carry out some fencing of the section to prevent unacceptable poaching levels. It is recommended that any fencing is set well back from the bank, with gated access to allow for some grazing. Also, if the walls are removed or dislodged then some natural erosional processes will start to occur and the river will need space to move - any fencing set too close to the bank is likely to be quickly undermined. In addition, there are few trees on this section. There is an opportunity to plant native trees on the open land adjacent to the river (Photos 3 and 4). These should also be set back from the bank to allow some bank movement. However, if planted, they should soon provide some natural bank protection, as well as shelter for animals. It is recommended that any planting is completed in clumps, at identified potential areas of erosion, rather than linearly along the river course, and using a mixture of trees and native shrubs.

Downstream of Stubbins Bridge, there are some buildings on the left bank that appear to be derelict (Photo 8), but it is assumed that this area will be redeveloped at some point. A tributary (the Dearden Brook) joins at this location and can be seen cascading over the sheet piling towards the top of Photo 8, just downstream of the building on the left bank. As part of future redevelopment, the riparian habitat here could be naturalised and improved by removing the sheet piling and concrete bank, and creating a gently sloping bank profile with associated trees and other vegetation. This would allow a more natural confluence of the tributary with the Irwell, improving its appearance and connectivity with the main river. If necessary, bioengineering-type solutions could be adopted as outlined in section 2.3 as an alternative, but a more natural approach is preferred.

At some locations along the river, particularly where walls are absent or have collapsed and the banks are bare earth, holes are visible in the banks which could be due to crayfish burrowing. There have been reports of the native White-clawed Crayfish along the Irwell, and bank profiles of this type are clearly of benefit to this species.

Close to the Cuba industrial estate is a distinctive meander bend. This has been identified in the Irwell Gravel Management Plan as providing an opportunity for flood water storage. For this purpose it would require the construction of a flood bund downstream which would be counter to river restoration activities. It is understood that this section is currently dredged in places by the landowner, and therefore it is assumed that he is trying to reduce flood event frequency onto this surrounding low lying floodplain area. However, the impact of this work is not known in terms of flood frequency modification. As discussed above, some relatively low cost conveyance modelling that evaluates the impact of increasing sediment bar size should give an indication of flood level impacts and potential flood inundation frequency. The area is currently grazed and set to grassland. If the farmer was willing to enter a stewardship agreement, this should help improve this section and restore natural river and floodplain processes and habitats. A mixture of wet woodland and wetter scrapes would provide additional habitat benefit. Interestingly, there is a weir marked

on the map, but this appears to have blown out in the past. This is a good example of natural river process recovery, with riffles forming downstream of its previous location, and bank and bed adjustments upstream to accommodate the new flow regime.

Where the Cross Bank Brook joins the Irwell between Stubbins and Ramsbottom, a makeshift culvert has been put in place to provide a crossing (Photo 11). This does not appear to be an official structure and should be removed if possible as it is likely to be impeding flow in the brook.

In North Ramsbottom, just south of the Cross Bank Brook, before the mills at Peel Brow, there are what appear to be some original flood terraces on the left bank (Photos 13 and 14). It is possible that the original course of the Irwell ran slightly further east in this area and has since been diverted. However, no evidence for this could be found on a historical map dating back to 1850.

Just upstream of Ramsbottom Bridge, there is a weir large enough to prevent fish passage (Photo 17). A fish pass in the form of a bypass channel has been put in place on the right side (to the left of Photos 15 and 16).

**Summary of recommendations**

- Remove or set back flood banks at Chatterton.
- Add riparian vegetation and if necessary fence sections but make sure well back from bank.
- Restore floodplain connectivity close to Cuba industrial estate.
- Remove sheet piling and concrete bank at Stubbins Bridge where the Dearden Brook tributary joins the Irwell.
- Remove the unofficial culvert at the Cross Bank Brook confluence.

## *2.4 Map 4 – Summerseat SD79531659*

*Visited Wednesday 21st January 2009 (pm)*

This whole section has clearly been impacted by a range of industrial changes over time. The first series Ordnance Survey (OS) historical map (1850) clearly notes a range of industrial uses along the river course including print works and cotton and wool mills, with other mills continuing to flourish and increase in numbers for a considerable time after this. Tipped material (concrete slabs) can now be seen on the right bank in Photo 1. The railway bridge (Square River Bridge) can be seen in Photo 3 (upstream end) and Photos 6 to 8 (downstream end). Crumbling walls can be seen towards the left side of Photo 6 and are a particular problem around and underneath the bridge. The NFCDD database shows this section of river to be a natural channel. In terms of its planform, it is still fairly sinuous through this section, retains a riparian corridor and now much has been converted to parkland with limited industrial use. The industrial legacy however, is still evident in the form of weirs, off-takes and aqueducts. Whist the river form is sinuous, this was clearly set in its current course via historical bank protection, quite likely introduced when the railway line was built. In terms of allowing natural river processes to be restored then, continuous degradation of the walls seems beneficial. However, it is impossible to say what the impact of this might be in terms of planform changes, and over what timescale any adjustments might occur. The meandering form would suggest reasonable stability in this section of the Irwell, and indeed within Nuttall park, any minor adjustment to planform should not be seen as major issue. However, it is recommended that this section is periodically monitored using fixed point photography to ensure there is not an impact on the railway line or the mill.

Photos 4 and 5 were taken from outside the mill at the bend in the river, across the railway embankment from Nuttall Park. There is a relatively small, privately maintained weir at this location (Photo 5), and the left bank is walled alongside the mill (the right bank is more natural). Removal of this weir would improve continuity along the river, assuming that flood risk to the adjacent mill buildings, which are currently being used as a business premises, is not increased. It is not known why this weir was introduced - whilst the mill was constructed some time between 1910 and 1930, a weir is still not present even on the 1937 map. The reason for the introduction of this weir should be assessed before removal to ensure that it was not introduced to prevent headcutting upstream for example. If there is a specific reason for the introduction of this weir that makes its removal problematic, then alternatives could be considered to improve fish passage and continuity such as a rock ramp, as illustrated in Figure 4.

Photo 11 shows a view of Nuttall Park from the south-east corner. The majority of the park consists of very informal, open grassland of limited biodiversity value. There are also some fairly large areas of Rhododendron and Japanese Knotweed around the edges of the park (in fact Japanese Knotweed is a problem along the entire river corridor). This area has been identified in the Gravel Management Plan as a potential flood storage area. However, this would require the construction of a flood bank along the edge of the river downstream of Nutall park. This would be counter to the ethos of restoring connectivity laterally to the floodplain and as the Gravel Management Plan states, it is questionable whether such an option is cost-effective in terms of preserving park infrastructure. In addition, the floodwater must extend beyond the limit of the suggested new flood bund thus reducing the area of the floodplain at that location. Such a scheme would need to include a significant amount of detailed hydrological modelling to ensure it can be deemed beneficial and is not having a detrimental impact outside the scheme limits, either in terms biodiversity issues or flood risk (especially upstream). Whether or not such a scheme is deemed beneficial, this area could be significantly improved by creating more informal/diverse habitat niches through the creation of a much more diverse wetland/marsh area, as discussed elsewhere in this report.


**Figure 4: Rock ramp installed behind a dilapidated weir or the River Neb, Isle of Man. A: Weir before works. Photograph: Dept Transport, Isle of Man Govt. B: Partially drowned-out weir after installation of ramp. C: View of ramp, looking upstream.**

Photos 29 and 30 show a gravel shoal placed on the river bank, which has been removed by dredging. The Gravel Management Plan and the Upper Irwell Fluvial Audit have both already noted that this section is always likely to be an area of deposition due to its locally low gradient. Clearly, dredging is not a sustainable solution at this reach and is likely to be having a locally significant negative impact on bio-diversity issues. Furthermore, the currently procedure appears to be to remove the shoals periodically and place the spoil on river bank. This unconsolidated material is likely to re-mobilise during flood events and end up back in the river. In addition, since the material is remaining within the confines of the river, it is unlikely to increase local capacity of the river, and therefore it is questionable whether this practice is either sustainable or beneficial in terms of flood risk reduction. Along the section that is currently dredged, there are two bridges on the Irwell and another at the downstream section of the Holcombe Brook. At this downstream end of the Holcombe Brook confluence there are 3 small culverts under Waterside Road at

Summerseat (Photos 26 and 27). There may be potential to improve the aesthetics of this entry point. The reason for the 3 culverts under the bridge is not known and may be related to its structural integrity. It is recommended that any opportunity to improve connectivity at this point is included in options to use the play area on the left hand side of the brook as a flood storage area. Any changes at the confluence will be integral to such a scheme.

It is not known how much of the impact of backwater effects during flood events is due to the capacity of these bridges, as opposed to the accumulation of gravel material. It would be beneficial to complete some modelling using HEC-RAS or ISIS to evaluate the impact of the bridges versus the impact of the gravel bars. Whilst the RRC would not normally advocate the use of raised hard engineering defences, in this case (along the edge of Holcombe Brook) this maybe the most appropriate solution to the problem, and it is recognised that the houses are extremely close to the watercourse at this point. However, should such a solution be deemed necessary, any defences should ideally be set back as far as possible and include vegetation recesses. As discussed in section 2.2, an alternative would be to re-landscape the gardens of the properties at risk, thus allowing the river more natural 'floodplain' space.

Downstream of this section, the river becomes much less modified although even here, past quarrying and mills will have had an impact. However, especially in the Nuttall area (Photos 15 and 16, 20 and 21) there is clear evidence that the river is now working with natural processes to create a range of habitats within the watercourse.

**Summary of recommendations**

- Remove weir adjacent to the mill at Nuttall Park if there is no likely negative impact on rail infrastructure upstream, or alternatively look for rock cascade options to replace weir.
- Improve the riparian environment through Nuttall Park, reconnecting the river with its floodplain and improving the habitat value of the area. The solution suggested in the Gravel Management Plan would need a very careful cost-benefit analysis which includes the environmental aspect.
- Eradicate invasive species along the river bank.
- Improve the confluence of the Holcombe Brook and the Irwell at Summerseat.
- Review dredging practices so that they are in accordance with the Environment Agency's gravel policy.

## *2.5 Map 5 – N. Bury SD79461436*

*Visited Wednesday 21st January 2009 (pm)*

An old collapsed weir can be seen in Photo 3. As the majority of this weir has disappeared, there is unlikely to be much value in removing the remainder.

There are some areas of the bank in this area that are open and lack trees (Photo 9), particularly on the stretch of river upstream of Burrs Country Park. Both the habitat value and visual appearance of the river corridor could be improved through planting of native trees and riparian vegetation, although the potential for this will be limited where farmland extends down to the river banks. An alternative would be to fence off the river, thus reducing stock access and allowing for natural plant recovery. As discussed in section 3, any fencing should allow for some animal access.

There is a very large, privately maintained weir (Photos 10 and 11) just upstream of Burrs Country Park, which is likely to impede fish passage; installation of a fish pass could be considered as removal of such a large weir is likely to be expensive and impractical.

However, running through the park and continuing southwards there is a back channel (in fact, the canal feeder for the Manchester, Bolton and Bury Canal) that is owned by Bury Council (Photo 12). Photo 15 shows the canal feeder outfall just downstream of the park at Higher Woodhill. This feeder, historically, was needed as a water supply to feed the header reservoir at Elton when the canal was operational. It may be that this could be used for fish passage instead of the installation of a typical fish pass over the weir. This would be beneficial in terms of being able to support a greater range of fish than any particular fish ladder over the weir. Conversely though, it would require a significant amount of modelling of the flow splits and in-channel design to ensure stability, especially at the downstream end of the canal feeder. In addition, fish surveys and assessment would be beneficial to establish whether the fish are likely to use this new route, and also to ensure that the gradient is suitable. This has been flagged up as a potential option within this report but would require a significant, additional site-specific study to confirm suitability.

It should be noted that there are some weirs that have been installed in the river by canoeists (Photo 13). These, in their existing form, are incompatible with the restoration of this watercourse, and should ideally be removed or modified. However, in this case it is recognised that they provided a significant local amenity and this probably outweighs any requirement to remove them, especially since it is understood that these weirs are passable to fish during high flow events.

**Summary of recommendations**

- Planting of native trees and riparian vegetation or fencing-off with space for some grazing and natural vegetation regeneration, particularly in the more rural area upstream of Burrs Country Park.
- Improve fish passage at the weir at the northern end of Burrs Country Park.

## *2.6 Map 6 – Bury, Kirklees 1 SD79851254*

Through the outskirts of Bury, the Kirklees Brook is considered to be relatively natural in appearance, taking into account its industrial legacy (e.g. Photos 1, 16, 19).

### 2.6.1 Kirklees

Alongside and downstream of Olive Mill at Woolfold, ending at the top of the old ponds on the left bank, approximately 400m of the brook is channelized and both the bed and banks are lined with concrete, which is privately maintained (Photos 8 and 9). This section is very unnatural in appearance and even though the water quality is thought to be good it will provide a very poor habitat for wildlife. The mill is no longer in use so there is potential for this concrete to be removed, especially as there is development taking place on the old mill site close to the right bank (Photos 6 and 7). Ideally, some space should be left for the river (i.e. avoiding building right up to the bank edge, leaving a riparian corridor instead). It is understood that as part of this development there is a requirement to remove the concrete bed, and this is part of the Land Drainage Consent. It is also understood that the developers are proposing to include a natural cobble bed dispersed with small, passable check weirs.

**Figure 5: Small 'check weirs' on Tilmore Brook, Petersfield. Note the gravel being held behind the structures.**

There are various projects of a similar type that have been completed, or are in the process of being designed in the UK. At Tilmore Brook (Petersfield, Hampshire), small check weirs were introduced to prevent head cutting, with new walls installed to replace sheet piling, using natural stone with crevices to allow the growth of vegetation. These walls were also slightly stepped back. Over time this section has begun to naturalise with vegetation and gravels (see Figure 5). Similarly, on Tanners Brook (Newport, Isle of Wight) a small project is being designed where a concrete bed is to be removed without impeding the structural integrity of the bank walls. This project is being led by the FRB team at the Hampshire office, Colden Common. Other initiatives have also been completed such as that on the Inchewan Burn, at Birnam in Scotland. Here, a gravel and cobble bed was designed-in where previously a Reno (gabion) mattress bed-lining structure existed to prevent down-cutting. The result was more of a pool-and-cascade section which looks more natural than hard-engineered weirs (Figure 6). The objectives of this work were to restore free passage for fish; to allow natural sediment transport; and to mimic a natural section of the burn with regard to landscape and aesthetic benefits.


**Figure 6: Replacement of gabion mattress with cobble pool-and-cascade, Inchewan Burn, Birnham. A: Before. B: After.**

Any of these options would need to be specifically designed to mimic appropriately the more natural sections of the Kirklees Brook, particularly in terms of the use of appropriate bed material. Whatever technique is used on this part of the Irwell, it must balance the aesthetic needs of the project with a design that is sustainable, to ensure that there are no negative impacts up- or downstream, should the river bed become more naturalised. The key concern is possible head-cutting due to the channel dimensions/local slope. The likelihood of this occurring needs to be assessed, and any design will need to undergo a detailed feasibility process.

Downstream of Olive Mill, the Kirklees becomes more natural in appearance for a short stretch, before becoming more modified again as it nears its confluence with the Irwell (e.g. Photos 23 to 25). Throughout this last stretch there are a number of structures (buildings and bridges etc.), and litter and other industrial debris are visible on the banks and within the river channel itself. At the confluence with the Irwell (Photo 26), the Kirklees channel is masonry-lined on the right bank and the bed is concreted. There may be an opportunity to remove the concrete bed at this point, however, the stability of the wall would need to be checked. There is some space on the left bank at this point and therefore there is a real opportunity to improve this section, from a local, aesthetic perspective. The current wall could be hidden and stabilised using the crushed concrete from the bed (see similar example, Figure 7), held by wire and netting with soil and slow growing willow (or similar), which would help to ensure stability of this bank. Any design would need to ensure that flood capacity is retained.

Again, there are a number of relatively small weirs on the Kirklees that could be removed to improve the flow regime (e.g. Photo 5, Photo 20).

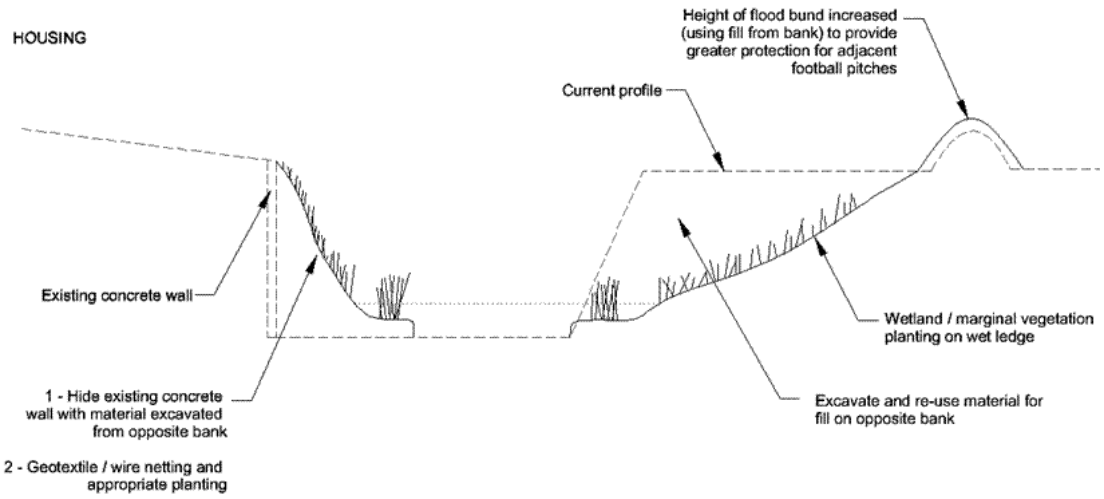


**Figure 7: Schematic of concrete bank wall hidden with excavated material. Connswater, East Belfast.**

## 2.6.2 Irwell

The main River Irwell itself is relatively natural in the area immediately downstream of Burrs Country Park. There are some good examples of gravel shoals and islands (e.g. Photos 31 and 33), although trees have been removed from a short section of the right bank, leaving it bare (Photo 32), presumably to avoid interference with the telegraph wires above. Large-scale removal of trees along the river corridor should be avoided where possible.

There is a privately maintained weir just downstream of the viaduct near the industrial estate at Fernhill (Photo 41), which is creating an obvious backwater effect upstream (Photo 40). This weir is in poor condition and is collapsing, and might represent a barrier to fish passage. It could potentially be removed, but this might affect the stability of the bridge upstream, as flow velocity in the area of the bridge would be increased. There are, however, other opportunities to improve passage through this section. One option worth considering at this location would be to create a cascade, as in the River Neb (Isle of Man) example discussed in section 2.4 (Figure 4). An alternative might be to remove only part of the weir to improve fish passage, but this would require stabilisation of the remainder of the structure, and it may still have an impact upstream in terms of gradient changes. A cascade is likely to be the most 'sound' and *relatively* inexpensive option. For example, in the Isle of Man case study, the new cascade cost approximately £80K, rather than the £250K it would have cost to refurbish/replace the existing, crumbling weir.

There is a second, much larger weir further downstream on the Irwell nearer the confluence with the Kirklees (Photo 48), which is privately maintained. This is estimated to be at least 4-5 metres in height and its removal is currently considered to be impractical. There is also a residential area extending very close to the right bank, with implications for flood risk if the weir is removed. Installation of a fish pass is one option. However, this whole section, along the river from the Industrial estate (see photo 40- SD80251181 to Cherry Tree Lane (SD79581035), flows through a section of river that is proposed for major redevelopment, with aspirations to improve the corridor for amenity value (see http://www.bury.gov.uk/NR/rdonlyres/87DFAADE-A2A6-43BC-B9EE-B4D4F4C543F7/0/BBBNewsletterWeb.pdf). There is a clear opportunity to encourage biodiversity (potentially including weir removal) and local community improvements along the watercourse in this whole section. In particular:

- Weirs could be removed or redesigned to improve fish passage. This should ideally include the large one upstream of the Kirklees confluence, discussed above (see comment below).
- Set back the development, thus allowing space for the river.
- Informal access could be included along the edge of the river, with any necessary flood defence set back behind this.
- Introduction of ponds and wetland areas which can operate as sustainable drainage such as that proposed near to the confluence with Kirklees Brook at site of an old mill ( see photo 57).

*Additional comment on large weir at Kirklees confluence:* The impact and backwater effect upstream is likely to be significant at this location, and opportunities to remove the structure must be considered in conjunction with river restoration options, since its removal will have a significant impact on water levels etc. This type of approach has been completed successfully in the states (see Appendix C). If such an option is deemed impossible, other options could be considered, including the introduction a fish bypass channel alongside.

Similar weirs also exist close to the B8214 road bridge and close to Tentersfield. In all cases, fish passes, removal or cascades should be considered. It is recommended that such options are built into planning policy at an early stage, so as to provide the Environment Agency with a way of positively influencing the planning process.

The importance of considering reconnecting people and wildlife to rivers in urban settings is outlined in the London Rivers Action Plan (available at http://www.therrc.co.uk/lrap.php), in which examples of river restoration activities can be found that could be implemented along this section, with appropriate local technical design.

**Summary of recommendations**

- As far as possible, remove concrete bed and banks from the Kirklees Brook at Olive Mill, Woolfold.
- Evaluate options to improve crumbling weir at Fernhill to improve fish passage; options may include cascade or partial removal.
- Evaluate options to improve fish passage, ideally through use of bypass channel. Where this is not feasible and weir removal is not possible, consider replacing with rock ramps.
- Much of this section should be considered in the context of the wider Bury development aspirations.

## *2.7 Map – Kirklees 2 SD77461382*

Towards the top of this stretch, at Brookhouse Mill, the banks are supported by sheet piling (privately maintained) through an industrial area, as seen in Photos 8 to 10. This highly artificial method of bank support presents no habitat value and is visually unappealing. Ideally it should be removed, but it is recognised that this is currently unlikely to be a cost effective suggestion, especially since it is so close to an industrial area. Nonetheless, if there were a change of land use, this piling should be removed or at least lowered, since it represents a considerable eyesore in an otherwise pleasant woodland area. Interestingly, along this section some natural

side bar features have formed, indicating that this section is over-wide for most flow conditions. Laying back the bank and, if necessary, stabilising with some geotextile-type techniques as discussed in section 2.2 (Figure 3) could significantly improve this short section if the opportunity arose, or when this asset requires replacement. The river is culverted for approximately 80 m underneath the industrial estate at Mill Road, but as can be seen from Photo 11, the industrial site is located on top of the culvert, therefore its removal would currently be impractical and would necessitate a change in land usage to allow for improvements along this section of the river.

There is a relatively small weir alongside the reservoir (Photo 16), and another just downstream of this that is beginning to collapse. The two weirs are clearly currently severely affecting fish passage. However, it is recognised that these were probably installed as part of the reservoir design and simply removing them could result in instability of the wall along the edge of the reservoir, which now has great amenity value as a fishery. Caution should therefore be voiced regarding this section in terms of just removing these weirs, especially since the gradient is locally unnaturally steep as a result of the significantly modified planform. A series of smaller step weirs using similar stone to that in the bank wall would help fish passage and would be in keeping with the local surroundings. Something needs to be done here as a matter of urgency if the current wall is not to be undermined as a result of the semi-collapse of the weir shown in Photo 17. An option similar to that illustrated by the example at Tilmore Brook (section 2.6) would be one technique to consider at this site.

There is a second culvert approximately 50 m in length downstream of the viaduct at Mill Street, just downstream of the reservoir. Photo 18 shows the entrance to the culvert, and Photo 19 shows the view looking north over the culvert. This area is part of a Local Nature Reserve (LNR) and there is a public footpath passing over the culvert. This whole area is littered with remnants of past industrial usage, and the first series OS maps (1850) clearly show a print and bleach works in the immediate vicinity. Whilst it is difficult to assess the exact historical purpose of this culvert, it is now crumbling, in disrepair and no longer necessary in terms of industrial use. Visually it is an eyesore through this LNR. Removal of this culvert would be beneficial not only from an aesthetic point of view, but may provide a relatively quick, low cost win in terms of increasing water body habitat, which is currently absent from this nature reserve area. Given its location, flood risk concerns to local properties which border the reserve can only be improved by allowing water to flood out onto the reserve during high flows. The soil condition at this point is unknown – it may be both unconsolidated and heavily contaminated. Both these issues may have a major impact on channel design and potential, but it is recommended that this opportunity is pursued.

On the bend in the river just downstream of the culvert, there is a large amount of collapsed stones and other masonry in the river channel (Photos 20 and 21), which is clearly a legacy of the industrialisation of this area. Although this is causing some degree of obstruction to flow, there is probably little benefit in removing it, as the river is likely to find a route around it. However, it is impossible to predict the degree of movement that might occur in this section of the river. Although there are no immediate negative issues surrounding any changes in river form, nonetheless, it is recommended that this section is monitored on a yearly basis using fixed point photography, to gauge any planform change. It may occasionally be necessary to remove some of the debris in this reach in the future. Contamination, may also be an issue in this reach and water quality testing would be beneficial.

In Photo 23, just downstream of the old print works, ochre was observed in the river at the bottom of the collapsing wall. This was also noted along other sections of the

river, and has implications for the removal of walls along the river, should ochre release be increased.

The weir just downstream of the old ponds (Photo 27) could be removed, but its small size is unlikely to be causing any problems for fish passage, and the cost of removal for this type of weir may well be greater than the resulting benefits.

Again, there are lengths of crumbling wall along this section of the river, although the NFCDD database states that the channel is natural (see Photos 28 and 29). Generally, however, the middle sections of the Kirklees are relatively natural in appearance (Photos 34 to 36).

Photos 40 to 42 show a privately maintained weir that has collapsed upstream of the new Kingsbury development. Rather than removing the entire structure, which might be expensive, fish passage could be improved by breaking up and removing some of the loose and collapsing stone and making good the remainder of the weir. The collapse of the weir has already resulted in some changes to the flow dynamics upstream. There is now no backwater impact evident. There is some slumping of the banks upstream of the weir and some trees have fallen as a result of the weir collapse. This has been observed in other sections of the Irwell where weirs have failed and is a natural adjustment process of the river. It is not thought however, that this adjustment will be major. Indeed, there is evidence in this section that much of the adjustment has already occurred, as small gravel side-bars are now beginning to form, which should help to re-stabilise the bank (see Photo 43). If there is any concern, it is suggested that either the Local Authority or the Environment Agency take some repeatable fixed point photographs perhaps once to twice a year (ideally after large flood events), to check the changes. Bank stabilisation work using natural materials is not thought to be necessary at this point, but it would be interesting and prudent to initiate monitoring, in the unlikely event that small sections become adversely affected.
The Kirklees has been diverted over a short section (approx. 350 m) at Kingsbury Close to allow a small housing development. The river used to run through the middle of the estate as it is now, but has instead been moved to the western edge, in an artificial channel (see the Kirklees map 2). This diversion channel is considered to provide reasonably good habitat. There are a number of 'cascade' weirs at the downstream end of the site (Photos 53 to 55), which were installed as part of the development. Whilst not perhaps the best solution, looking at it retrospectively, given the constraints at the site, this series of weirs have nonetheless been designed in such as way as to ensure fish passage is not impeded, and are half way towards a rock cascade technique, which might have been a better solution in terms of aesthetics. What is important to note at this site is that the diverted river is cutting down to expose old foundations (Photos 49 and 50) in places, and this should be checked from time to time to see if any remedial work is necessary.

Downstream of the housing development the river is quite natural, with, for example, gravel/cobble bars, boulders and relatively natural banks. Some sections are walled, but where these are collapsing this provides additional habitat within the bank (Photo 57). In places the river is eroding and depositing its channel, which has naturally shifted the channel position (Photo 59). This suggests that river processes are occurring as expected in this area, which, in this location, is beneficial and should continue to occur.

There is a large weir (Photos 61 and 62) downstream of the new housing development. This could be removed, but the time and cost involved should be weighed up against the likely benefits, especially given the recent channel diversion,

housing estate and series of weirs installed upstream. The impacts of weir removal at this point would probably outweigh the benefits. In this location, a weir bypass is likely to be difficult as an alternative option and therefore a fish pass is likely to be necessary.

Further downstream of this there is a length of gabion walling supporting the bank (Photos 66 and 67), which is marked as a natural channel section on the NFCDD database. This is rusting and in poor condition and is likely to collapse in the near future. It might be worth considering its removal and, if necessary, replacement with a semi-natural bioengineering option. Laying back the bank and installing low lying wooden 'walls', back-filled with soil and geotextile liner maybe one option. If with the design is to include local native bankside trees, these should quickly take hold and form a natural stable bank. Such a project has been completed on the River Char at Charmouth, close to a sewage treatment works (see Figure 8). Some future maintenance may be necessary (e.g. coppicing on occasions) to maintain structural integrity, but this should be low-key and low cost. It is assumed that bank stability is necessary at this location since extensive erosion may impact on the feeder channel to reservoirs downstream.


**Figure 8: Back-filled coir net terrace revetment, River Char, Charmouth. A: As built, in 2005. B: With vegetation establishing, 2006.**

**Summary of recommendations**

- Remove sheet piling bank support at Brookhouse Mill if opportunity arises in future. Could be replaced with bioengineering solution if necessary, or re-profile banks on wooden area.
- Remove small collapsing weirs adjacent to the reservoir downstream of Brookhouse Mill, and replace with a series of small drop weirs and designed-in 'holding pools' using local stone to improve fish passage.
- Investigate options for removal of the culvert downstream of the reservoir and replace with free flowing water course through local nature reserve.
- Improve fish passage at the weir upstream of the Kingsbury development.
- Install a fish passage structure at the large weir downstream of Kingsbury.
- Consider management options for the section of gabion walling downstream of Kingsbury, which could include removal of gabion structure (which is beginning to degrade), and replace with a more sustainable semi-natural solution.

## *2.8 Map – Kirklees 3 SD75991458*

Towards the top of Kirklees Brook at Hawkshaw, the river is relatively natural (e.g. Photo 4), although collapsing walls are still in evidence along the banks. However, there is very little tree cover on the banks in the section between Hawkshaw and Greenmount, as much of the surrounding land is grazed (Photos 7 and 8). If possible it would be helpful to introduce some native riparian vegetation and trees along the river banks in this area, to increase shading and improve the appearance and habitat value of the river corridor. For example, Photos 9 and 10 show a slightly more wooded section of river slightly further downstream. Most of this floodplain has been extensively managed and now primarily comprises improved pasture land, which has historically been drained (see First Series OS maps c1850) and has also supported a colliery and a sandstone quarry in the past. Now, however, there is the opportunity to create a mosaic of wetland habitats in this reach, including wetter scrape areas and more rush-type pastureland.

Throughout this stretch the river is relatively unconstrained and is therefore free to erode and deposit and form natural, morphological features such as pools, riffles, glides and bars. For example, Photos 16 and 26 show erosion has taken place on the outside of the bend, and deposition of gravel/cobbles and larger stones on the inside of the bend, with the channel morphology adjusting accordingly. The presence of such gravel/cobble bars and larger boulders/stones in the river channel increases flow variability and therefore the diversity of habitats present within the river channel.

There is a culverted section at Bottoms Hall cottages, approximately 60 m in length (Photos 11 to 13). Although de-culverting is a general recommendation along the Irwell and Kirklees, it may be difficult to remove all of this particular culvert, as part of it appears to pass directly under, or extremely close to, the cottages, whilst another section is under part of a garden. It may be possible to remove some of this culverted section but it would require agreement by the landowners. This culvert is mentioned in the Irwell Gravel Management Plan as a constraint on channel capacity and vulnerable to collapse. Whilst there is no sediment issue associated with the culvert currently, it is thought that this may not be the case in the future, which would further increase flood risk to the cottages. Therefore, opening up at least part of this culvert may alleviate such risk.

There is a privately maintained weir towards the end of this stretch, just downstream of a small footbridge (Photo 24). The weir appears to be of block stone construction and might be large enough to impede fish passage, at least of some species and some size classes. It is likely that the removal of this weir will affect the stability of the footbridge upstream, although the footbridge is not marked on the Ordnance Survey map so it is unclear as to whether or not it is an official structure. Historically, this section has clearly been stone-walled, most of which has subsequently failed and the majority of the section is now beginning to exhibit more natural erosional and depositional features, with the exception of this weir and bridge section. The best solution would be to negotiate with the land owner to see if a) a crossing is necessary and b) if it could be located elsewhere and form a temporary crossing point, which could be easily moved if necessary. This would enable the weir to be removed, which would be the ideal solution. In the meantime it would be very easy to remove part of the weir structure to create a notch type feature, thus improving fish passage.

**Summary of recommendations**

- Planting of native trees and riparian vegetation in the section between Hawkshaw and Greenmount, where land use permits, and creation of a wetland habitat mosaic with rush-type pastureland.
- Investigate the potential for removal of the weir between Bottoms Hall cottages and Old Keys Park.
- Remove the small weir, or modify with, e.g., notch feature

## *2.9 Map 7 – Bury SD79821108*

This is a very urban section of the river, with housing and industry located very close to the river banks along the majority of the reach. Generally, the issues affecting this stretch of river are similar to those affecting other urban stretches, with high walls protecting residential and industrial areas (e.g. Photos 8 and 15). Further downstream of Bury town centre, the river becomes more natural in appearance, with more natural bankside vegetation and trees and fewer buildings encroaching along the river bank. Photo 18 shows an example of a more natural section of the river, although there is a noticeable backwater effect here as a result of the large weir further downstream. There are a number of weirs along the river through Bury, primarily related to a historical milling legacy. The first of these is in central Bury, and can be seen in Photos 1 to 4. There is a second weir downstream of the Bolton Street road bridge (Photos 11 to 14). This weir is starting to collapse in places, but again the cost of removal should be balanced against the likely benefits. The largest weir in this section is at Buckley Wells (Photos 21 to 24). This weir appears to be in reasonably good structural condition but clearly impedes fish passage currently, due to its size.

The cost of removing some of these weirs (especially the one at Buckley Wells) would normally be prohibitively expensive. However, as outlined in section 2.6, Bury town centre has been identified as an area for urban regeneration, and opportunities for opening up the river corridor, setting back the new development, removing impassable structures for fish, making the whole river corridor link with community needs and reconnecting this community with the river environment should be seen as fundamental to the regeneration plan. Certainly, the removal of some of the weirs should be considered, particularly the one at Buckley Wells, since its impact on the Irwell is significant. However, it is recognised that the costs may be excessive (especially since it is assumed that there is a considerable amount of contaminated silt stored behind this weir). Whilst removal should be the first option to consider, it was noted that there is a bypass channel to the side of this weir. It was not possible to track the whole route during the site visit however, though within the redevelopment scheme, the opportunity for creating a bypass channel should also be considered at this location. Should removal of the weir be feasible however, this will need to be undertaken in coordination with wider river restoration initiatives, as outlined in section 2.6,

**Summary of recommendations**

- Consider the river as a central asset to the Bury regeneration programme, and through this process, improve fish passage, fluvial processes, biodiversity habitat opportunities, community amenity value and reconnection of the river with people.

## *2.10 Map 8 – N. Radcliffe SD79340909*

The upper reaches of this section are relatively natural, given the generally urban setting. A good example of a more natural area of floodplain can be seen on the right bank in Photo 4. There is a mostly disintegrated weir just downstream of the Metrolink line (Photo 5), the remains of which could be removed. It is unlikely that this weir is impeding fish passage, as the remains are mostly below the water line, but the river upstream is slower flowing and sediment transport is likely to be disrupted.

There is a very large, privately maintained weir just upstream of Bury Road (Photo 8), which will definitely act as a barrier to fish migration. Possibilities for improving fish passage at this weir should be considered, such as the installation of an appropriate fish pass structure. Complete bypass of the weir could also be considered. There is a channel running along the right bank of the Irwell past the weir (Bealey's Goit), which was completely dry at the time of the visit (Photo 12). It might be feasible to create a fish bypass route along part of this channel, as it is connected to the Irwell just upstream of the weir, and could be linked to re-join the Irwell just downstream of the weir. It is assumed, for the purposes of this report, that neither the Goit nor the weir still serve any specific function, since the mill and associated wheel are no longer operating. At the time of the site visit, although the section of Bealey's Goit that runs alongside the Irwell was dry, water was present in the channel further south, at Close Park, before it re-joins the Irwell. The function of the Goit needs to be fully investigated before the feasibility of modifying it can be determined, as would the effects of splitting the flow at this point, especially regarding any adverse impact on the main Irwell watercourse. It is also understood that there is a draft proposal to construct a hydropower scheme at this weir, and these proposals include the use of the Bealey's Goit channel. The impact on flows and fish passage will need to be included in any Environment Agency agreement on such a scheme. Complete removal of this weir is assumed to be cost-prohibitive but should not be ruled out if it no longer performs any function.

There is a large gravel shoal in the middle of the channel downstream of Bury Road (Photo 20). This was removed approximately 10 months ago, but has since re-formed to a significant size. It is recommended that this shoal is left in place as it is contributing to variability in flow and habitat, although it should be checked regularly to ensure that the channel does not become blocked and increase the risk of flooding, particularly as there is a school on the left bank. If necessary, sections of the shoal could be moved within the channel to re-direct flow where desired. As discussed in other sections of this report, an assessment of the flood risk associated with this shoal would be beneficial. The use of CES would provide a good indication of how overall changes in the maintenance strategy associated with the removal of gravel at this location might affect water levels at high flows. In addition, if changes are made upstream (in terms of fish passage and flow diversions) then this may have an impact on the sedimentation at this point. Interestingly, no deposition is identified on the historical maps until after the large horseshoe weir upstream of Bury Road replaced a smaller weir, around 1894.

It was noted that a number of the houses on the left bank of the river have taken over the river bank at the bottom of their gardens, and in some cases built structures out into the river itself (e.g. Photo 18). This has implications for bank stability and the collapse of bank material into the river is a real possibility. This area should be monitored regularly to prevent collapsed material from obstructing flows, and further modifications should be discouraged through a targeted information campaign.

Further downstream, in the loop of the river downstream of Hardy's Gate Bridge, the banks are surrounded by housing and industry (e.g. Photo 32). Owing to flood risk issues, the possibilities for enhancement here are currently limited. However, there are plans to redevelop this section. The proposal has identified the need to provide a new riverside park along the River Irwell and open this area up for public access. A significant amount of work has also been completed in terms of the flood risk assessment using an ISIS model. Within this assessment there is discussion about a 2 stage channel with a capacity to accommodate 1 in 100 year flow events. However, it is recommended that the detailed design of this cross-sectional form is discussed in more detail before final feasibility assessment. An indicative cross-section (Figure 9) from a report by Cube (2009) seems to indicate that the new river corridor within the development reach aspires to having less hard-engineered banks and that space has been made for the water, with the 1 in 100 year flood boundary and the 2nd stage channel extent designed to include the section identified for public access. Whilst this is extremely commendable and includes riparian wetland backwater features, nonetheless, the main river appears to remain trapezoidal in form. There needs to be more discussion about this part of the design (though it is appreciated that these are currently concept drawings). If design of the 1st stage channel is over-wide it may result in the perception that gravel shoal removal is necessary, which would add an additional and unnecessary financial maintenance burden for either the local council or the Environment Agency. In addition, any future sediment removal would be detrimental to any habitat gain due to the overall project and counter to the Water Framework Directive objectives.

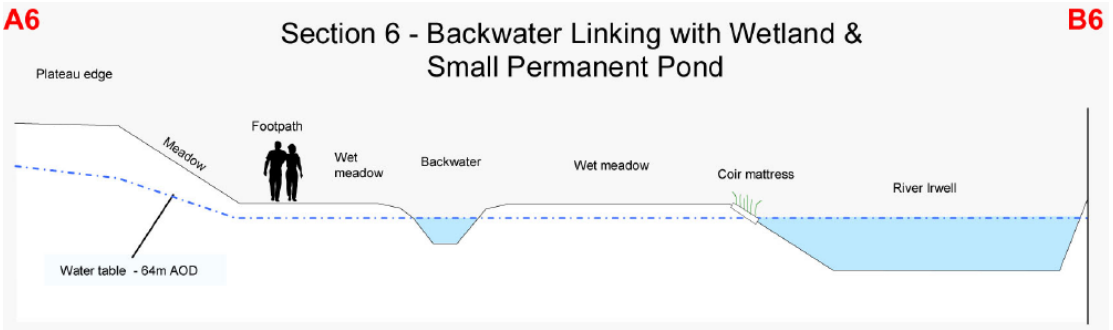


**Figure 9: Indicative cross-section across river Irwell downstream of Hardy's Gate Bridge. From: Cube Architecture and Design Ltd (2009) Dumers Lane, Radcliffe, Bury: Design and Access statement. Property Alliance Group Ltd ( www.dumerslane.com)**

Once the river reaches Springwater Park and beyond (Photo 35 onwards), it becomes more natural in appearance, with at least some trees and vegetation along the banks. Japanese Knotweed is a problem along much of the river in this area, and dead stands of Knotweed can be seen along both banks in Photo 40.

**Summary of recommendations**

- Remove remains of disintegrating weir downstream of the Metrolink line.
- Investigate options for improving fish passage at the large weir upstream of Bury Road, possibly through the creation of a bypass channel using a section of Bealey's Goit.
- Retain the gravel shoal but monitor its size and location, and maintain an open channel to prevent an increase in flood risk. Complete a modelling assessment to evaluate flood risk and look at impacts in conjunction with any changes to weir and flow splits upstream.
- Monitor the sections of modified bank/gardens for potential collapse and try to prevent further modifications.

- Eradicate invasive species along the river bank.

## *2.11 Map 9 – Radcliffe SD78940709*

The majority of this section of river is relatively urban, with housing and businesses located close to, and in places bordering, the river banks (e.g. Photos 2 and 3). There is a viaduct crossing the river near the industrial estate (Photos 5 and 8) but the footbridge marked on the map downstream of the viaduct no longer exists (Photos 9 and 10). The possibilities for enhancement are extremely limited here due to the close proximity of housing, businesses and other infrastructure.

At the downstream end, the river is surrounded by open land and trees, with a more natural bank structure and riparian vegetation (Photos 9 and 10). However, the invasive species Japanese Knotweed, Giant Hogweed and Himalayan Balsam were seen to be particularly prevalent along this section, and were particularly noticeable around the industrial estate; old Japanese knotweed stands can be seen in Photo 7.

There are flood embankments along the majority of the river length in this area, as can be seen to the right of Photo 6 and to the left of Photo 10. In this case it is unlikely that there is any opportunity to set back these flood banks to provide more space for the river, but it is worth noting that when new development options arise, any necessary flood banks should be set back from the river as far as possible to allow for the formation of a more natural bank profile without compromising flood protection.

**Summary of recommendations**

- As a longer term initiative, look to options to eradicate invasive species along the river bank.
- If future development opportunities arise, set back flood banks.

## *2.12 Map 10 – L. Lever SD77570643*

In general, this section of the river is now relatively natural, with trees and riparian vegetation along the banks and open land surrounding the channel. However, owing to its historical legacy, this section, and that downstream towards Kersley (map 11), is littered with industrial remnants. The most obvious of these are the weirs that cause a real impediment to fish in an otherwise relatively natural section of the river. Indeed, where weirs have already blown out, the benefits, in terms of restoring natural river processes and improving fish pass, are clear just through visual inspection. Therefore, in this whole section it may be worth considering the opportunities to remove some/all of these weirs rather than retro-fitting fish ladders, which is an expensive option in locations where weirs may no longer be necessary. It may be wiser to spend the money on complete removal.

More specifically, there are two large weirs in this stretch (see photos 5 and 6 and 11 -13). The first of these is privately maintained and just past the first bend in the river. It appears to be in good condition. This weir is quite large (estimated to be at least 3m high) and will almost certainly prevent fish passage upstream. At this location, there appears to be a bypass channel related to the old print works, on the right hand side of the river. Options for using this as a route for fish passage could be

considered as an alternative to either weir removal or a fish ladder. The other, larger weir further downstream near the disused bleach workings was difficult to access owing to the height of the banks and the thick Rhododendron growth. However, again, weir removal or fish passage improvement should be investigated, though it should be noted that such an option would need to consider contamination issues relating to silt stored upstream of the weir. Moreover, this would also require wider river restoration initiatives to stabilize neighbouring reaches in the short term, until a natural stable condition is attained.

The two smaller weirs marked on the map near the reservoirs have mostly disappeared (Photos 9 and 10) and are not considered to be a problem.

Invasive plant species such as Japanese Knotweed are again a very common problem along the river banks (e.g. Photo 8).

**Summary of recommendations**

- Eradicate invasive species along the river bank.
- Improve fish passage through a combination of techniques.

## *2.13 Map 11 – Kearsley SD76090665*

It is understood that the old Creams paper mill (photo 5) is now coming up for development and it is recognised that any consents process will require an improvement for fish passage in this section. There is one weir associated with this development, just upstream of Ash Clough, (see Photos 1 to 3). As discussed in section 10 above, options for fish passage throughout this section and upstream could be considered much more strategically, given that that there is currently very little infrastructure ( e.g. main roads and railway bridges) in this area that would be seriously affected by weir removal.

Downstream of this old mill location, the river and its banks are relatively natural (Photos 6 onwards), although the banks are very steep. There is an aqueduct just upstream of Prestolee Bridge (Photo 8).

A second weir exists at Prestolee (privately maintained) but due to thick vegetation and the gradient of the banks, it was not possible to access this location. However this is believed to be similar in size to the first weir on this river section and related to an old spinning mill which is no longer in use. As above, options to remove this weir as part of this whole reach could be investigated, although it is recognised that this weir is the one situated closest to any development, and the main railway line runs near to the left bank.

Photos 10 and 11 were taken from Prestolee New Bridge, and housing can be seen quite close to the river banks in both photos. Photos 14 and 15 were taken from the next bridge downstream, Ringley Bridge, which is also surrounded by housing. Flood risk will be an issue here. owing to the surrounding residential area of Kearsley, and there are steep flood embankments along much of this section. Similarly, Photos 12 and 13 were taken from the right bank of the river alongside a new residential development off Ringley Road. It is known that Japanese Knotweed is an issue in this area, and an attempt has been made to eradicate this plant in the area of the development.

**Summary of recommendations**

- Consider fish pass improvements as a priority, within a wider strategy (perhaps with external funding) for this whole section, and that shown in map 10.
- Eradicate invasive species along the river bank.

## *2.14 Map 12 – Ringley SD76270544*

*Visited Thursday 22nd January 2009 (pm)*

Photos 1, 2 and 3 were taken from the footpath alongside the river in Clifton Country Park, between the lake and the river, and looking across the river towards the Giant's Seat Nursery. The river and its banks in this area are relatively natural, with plenty of trees and other bankside vegetation providing good habitat diversity. This section could be used as a good example of the appropriate native vegetation when planning a planting scheme on other river sections.

There is a sewage works outfall (from Ringley Sewage Works) just upstream of the Giant's Seat Nursery, at a sharp bend in the river. The outfalls from this STW can be seen in Photos 5 and 8 to 10.

Photo 12 shows two gravel shoals forming islands in the middle of the channel. These will increase flow variability and should be left in place as long as the channel does not become blocked. As with many other examples along the Irwell, this accumulation of sediment at this location appears to be directly related to the large weir upstream (SD 76420482). This weir, initially constructed as part of a system to keep local coal mine shafts free of flood waters, and was subsequently used to supply cooling water to Kearsely coal burning power station until its closure in 1980. It is assumed that the weir is now redundant. This is a large construction and is a major fish pass issue for many kilometres upstream, even if other weirs are made passable. As discussed above, opportunities to improve passage at this weir should be considered in conjunction with the other structures in this area.

**Summary of recommendations**

- Retain the gravel shoal islands.
- Look for wider opportunities to improve fish passage throughout this whole reach and upstream.

## *2.15 Map 13 – Clifton SD77730409*

*Visited Thursday 22nd January 2009 (am)*

Photos 1 and 2 were taken looking upstream and downstream, respectively, from outside the Works at Clifton Green, accessed from the footpath off Castle Way. Photos 3 and 4 were taken a little further upstream opposite the disused Sewage Works, both looking upstream. There are no weirs along this section of the river and it generally looks relatively natural with quite thick bankside vegetation and trees. No specific enhancements are recommended for this section.

An aqueduct goes over the river close to Clifton Green and Hogg's Bridge. This is no longer used and there are many trees growing on top of it. It could be removed. However, the expense incurred, relative to benefits, currently makes this option

questionable, but it has been flagged up as a potential future opportunity if the surrounding area is to be redeveloped.

**Summary of recommendations**

- No specific recommendations are given for this section except potential future removal of the aqueduct if redevelopment occurs at this site.

## *2.16 Map 14 – Forest Bank SD79370347*

*Visited Thursday 22nd January 2009 (am)*

Photos 1, 2 and 3 were taken from the right bank, just upstream of Agecroft Road, Forest Bank. They show a good example of an area of relatively natural riverbank. Photos 5 and 6 show trees growing in the water at the edge of the bank, again providing an example of a natural bank with good habitat diversity. Photo 7 is looking north (upstream) along the footpath on the right bank, and Photo 8 is taken from the nearby footbridge looking downstream back towards this area. Photos 9 & 10, and 11 & 12, are two pairs of photos (upstream and downstream) taken from two points on the right bank towards the northern end of the map (Clifton Junction). Again, the river, its banks and the bankside vegetation are relatively natural along this section of river, with good footpath access and parkland surrounding the footpath. There are no weirs along this section.

Photo 13 was taken near Agecroft Bridge and shows a (presumably natural) backwater area, again providing good habitat diversity. This type of habitat feature could be incorporated into future bank re-profiling on other, less natural sections of riverbank.

**Summary of recommendations**

- No specific recommendations are given for this section.

## *2.17 Map 15 – Lower Kersal SD80850162*

*Visited Thursday 22nd January 2009 (am)*

Photos 1 and 2 were taken from the footbridge in Lower Kersal, accessed from South Radford Street. There is a reasonably large area of grass and scrub on the left bank between the river and Kersal Way (Photo 3). This could represent a good opportunity to create a small wetland area for wildlife bordering the river, which would also benefit the community in terms of recreation and social cohesion. The playing fields on the right bank, within the loop of the river, are the location of the proposed second flood basin for Salford. There is a great opportunity to think about this area in terms of creating a flood basin which would introduce biodiversity benefits to this section. Much of the playing field area is fairly informal and could be turned into a wetter, wildlife area with semi-permanent ponds (scrapes) etc to support a greater diversity of species and an informal nature reserve. In addition, it is understood that the University is planning to move from this site, and therefore the football pitches etc. will no longer be in use. The opportunity to enhance this whole section and create much more natural wetland/floodplain habitat is therefore potentially very high. Instead of increasing existing flood bunds, these should be set back to allow the loop to be better connected to the river here. This type of approach has been successful in a number of other locations, and examples can be found in the London Rivers Action Plan, as mentioned in section 2.6.

Photos 4 and 5 were taken from the Jubilee footbridge, accessed from Littleton Road. The banks in this area are grassy and relatively steep. Photos 6 and 7 show the weir downstream of the footbridge from the right bank, and Photo 8 is taken looking downstream from the weir, towards Littleton Bridge. Photos 9 and 10 are at the same location and show scrubland with redevelopment potential on the right bank of the river. On the day of the site visit, the water levels were relatively high and it was impossible to establish the structural state of the weir. However, it was clear that in most flow conditions, it provides an impediment to fish. It is a relatively small weir (compared to many) and appears to be the legacy of an old cotton and bleach works which no longer exist. The best option here (assuming the weir is not already naturally degrading) would be to remove this structure. The main checks that should be made prior to removing this weir are that a) it does not have an impact on the bridge conveyance downstream (from the walk over survey this is not thought to be an issue, but would probably need to be modelled); and b) check if there is likely to be any structural impact on the footbridge upstream (although it assumed that this would be re-designed to accommodate any changes). Some bank revetment changes might be necessary as a result of the weir removal but these are thought to be minor. If weir removal is currently not an option, then creating a notch would be a very beneficial alternative.

Photos 11, 12 and 13 were taken from Littleton Road, looking north and west over the playing fields and towards the river. These fields form the new Salford Flood Basin, which was used for the first time in January 2008.

**Summary of recommendations**

- Investigate potential to improve the scrubland at Kersal Way, perhaps creating a more visually attractive and wildlife-friendly wetland area bordering the river.
- There is a great opportunity to increase habitat heterogeneity within the loop area at the Castle Irwell site.

## *2.18 Map 16 – Salford SD82130032*

*Visited Thursday 22nd January 2009 (am)*

Photos 1 to 3 were taken from Hough Lane Bridge in Salford, looking north (upstream). There are grass-covered flood banks on both sides of the river along this stretch, protecting the nearby housing. On the left bank, the housing reaches right up to the river (Photo 3), whereas on the right bank, there is a recreation ground between Hough Land Bridge and Wallness Bridge. In this area particularly, it would be possible to move the flood banks further back from the river to create a more natural bank profile with a more gradual slope.

Photos 4 to 6 were taken from the foot bridge on the other side of the bend in the river, looking south (upstream) towards the Adelphi weir, where fish passage is again impeded in most flow conditions. There are some industrial buildings on the east (right) bank (Photo 6), so the bank is a brick wall at this location and opportunities for enhancement are currently limited. The Adelphi weir itself can be seen in Photos 7 and 8 (Photo 7 looking upstream and Photo 8 looking downstream). This is the downstream extent of the survey for this project. Given that the weir is a) within the confines of the regeneration area for the Irwell City Park; and b) within the area where there are proposals to look at the state of the sheet piling, it is essential that fish passage is considered sooner rather than later at this location. A fish ladder or notch may be one option, but a rock cascade should also be considered, given the

weir's proximity to other infrastructure which may necessitate continued stability at this section (i.e. little room for in-channel morphological adjustment).

Photos 11, 12 and 13 were taken from the footbridge between Peel Park and Meadow Road. The University of Salford buildings marked on the map alongside Meadow Road have been demolished (Photo 13), and this land now appears to be derelict. Photos 14, 15 and 16 were taken from the footbridge in Charlestown between Gerald Road and St Boniface Road. The close proximity of housing to the river limits restoration options in this area. However, there are opportunities for some small enhancements to be made. For example, Photo 17 was taken looking north from St Boniface Road, just at the bottom of the foot bridge. This shows a small area of open land that appears to be unused. The concrete and brick Environment Agency flood wall (Photo 16) between this area of land and the river could be removed and re-profiled where housing isn't present, to create a more natural bank profile. It is understood that much of this area is coming up for redevelopment under a Salford local government initiative and there are also opportunities to improve the river corridor and the bank protection work (i.e. alternatives to the current sheet piling) along much of this section which has been identified as beginning to fail. Throughout this report, reference has been made to various alternative bio-engineered bank protection and set-back defence methods, some or all of which could be integrated into this section. The important aspect to note with any redevelopment is to try to set back defences as far as is practical. This allows space for the river and the opportunity to include morphological and hence habitat heterogeneity within the scheme, whilst maintaining river capacity to ensure the flood defence standards are maintained. The other advantage of such an approach is that it should reduce future maintenance issues, especially in terms of reducing/negating the need to remove gravel bars and other sediment accumulation.

**Summary of recommendations**

- Look for options to improve river corridor and allow space for the river to move, as part of the proposed urban redevelopment.
- Improve fish passage at Adelphi weir.

# 3 Comparison with Water Framework Directive objectives and actions

The River Basin Management Plan (RBMP) for the North West River Basin District describes the catchment as largely rural at its source, but becoming walled and canalised as it flows through historically industrial towns such as Bolton, Bury, Salford and Manchester. Increased flood risk due to culverting is identified as a particular issue around Salford. Water quality in many water bodies has improved over the last few decades, but currently no water bodies are achieving either 'Good' or 'Good ... Potential' status.

Annex B of the RBMP identifies hydromorphological mitigation measures currently absent, and future plans. These are identified for some stretches of the Irwell, but they are not directed towards specific locations along the river. For the stretch between Rawtenstall and Edenfield (covered by Maps 1 and 2), the current overall status is Moderate and the ecological potential assessment for hydromorphology is Moderate or worse, and as a Candidate Heavily Modified Water Body, it is recognised that Good Status will be difficult to achieve, with the proposed overall status objective being set at Good Potential by 2027. Hydromorphological mitigation measures are identified as:

- Removal of obsolete structure(s)
- Removal of hard bank reinforcement/revetment, or replacement with soft engineering solution
- Preservation and, where possible, restoration of historic aquatic habitats
- Increasing in-channel morphological diversity
- Re-opening existing culverts
- Flood bunds (earth banks, in place of floodwalls)
- Improvements to floodplain connectivity
- Structures or other mechanisms in place managed to enable fish to access waters upstream and downstream of the impounding works
- Retention of marginal aquatic and riparian habitats
- Sediment management strategies (develop and revise)
- Appropriate techniques to align and attenuate flow, to limit detrimental effects of these features
- Educating landowners on sensitive management practices

For the stretches between Edenfield and Kearsley, the current overall status is Moderate, with a target to reach Good status by 2027. No hydromorphological mitigation measures are given. The stretch upstream of Rawtenstall is also classed as Moderate, although this was not part of the current survey. Similar hydromorphological mitigation measures are recommended.

The Kirklees Brook has not yet been assessed, so no current overall status is known. It is, however, listed as a Candidate Heavily Modified Water Body.

Annex C sets out tables of the actions (programmes of measures) that are proposed for each sector in order to achieve the objectives of the RBMP. Physical modification is listed as a pressure in all sectors, with actions such as: "reduce impact from hard bank reinforcement"; "protect, enhance and restore marginal and in-channel habitats"; "increase habitat morphological diversity"; "improve and maintain fish movement"; "improve connection to floodplain"; "and put in place appropriate plans for sediment,

vegetation and channel maintenance". This generally applies to all affected water bodies in the Northwest RBD where these actions will achieve good ecological potential.

The WFD assessment and programme of measures is in overall agreement with the recommendations given by this report, although the WFD assessment does not pinpoint specific locations for actions on the Irwell. Highlighted issues include: removal of obsolete structures such as weirs, or the installation of fish passes where this is not possible; removal of culverts; and naturalisation of the river banks by removal of walls and revetments in certain areas, including the use of earth flood banks instead of floodwalls, with subsequent improvement in floodplain connectivity. It is acknowledged that the river as a whole is modified as a result of historical industrial activity, and that the possibilities for enhancement will therefore be limited in some areas.

# 4 Summary table of options

The table that follows outlines the key options that have been suggested in section 2.

Options are categorized into the following issues and sub-issues:

1. Bank protection
    a. *Intact concrete walls*
    b. *Intact sheet piling*
    c. *Collapsing walls*
    d. *Failing gabion baskets*
    e. *New floodwall options*
2. Weirs
    a. *Intact*
    b. *Collapsing*
3. Floodplain
    a. *Enhancement*
    b. *Storage*
4. Riparian vegetation
    a. *Enhancement*
    b. *Invasives*
5. Dredging
    a. *Concrete bed*
    b. *Reduce/stop intervention*
6. Culverts
    a. *Intact*
    b. *Collapsing*
7. Wholesale urban redevelopment

This table is compiled on a reach by reach, or in many cases weir by weir basis. Whilst each of these represents and opportunity in its own right it is highly recommended that many of these options are not looked at in isolation, since their benefits, especially in the case of consecutive weir removal for example, are multiplicative and interactive.

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 1 – Rawtenstall***<br><br>***Section 2.1 pp 5*** | 1c<br>Bank protection - collapsing walls | Crumbling/collapsing wall:<br>a) Do nothing and allow to crumble<br>b) Take active action to remove | SD 8058 2227 | 650m | • Landowner agreement<br>• Assessment of flood risk/need to move back embankments<br>• Will require some maintenance to remove wall spoil from bed but only when a potential flood risk<br>• Ensure monitoring is completed of wall with fixed point photography | • Restoration of in-channel morphological processes.<br>• Some habitat gain. | M – both options a and b | a) L<br>b) H |
| | 2b<br>Weir collapsing ( M)<br><br>(Fish passage/ disconnection of river) | a) Do nothing and allow to disintegrate<br>b) Removal of weir | SD 8020 2218 | N/A | • Impact on water levels upstream<br>• Impact on walled section upstream although – may increase rate of current collapse - benefit or issue?<br>• Check to ensure there is no water resource issue | • Improved conveyance/ connectivity through reach.<br>• The formation of natural channel features<br>• Removal of backwater impact<br>• Fish passage improvement | M/H – both options a and b | a) L<br>b) H |
| | 2a<br>Weir intact (H) | a) Removal<br>b) Fish pass | SD 7990 2140 | N/A | • Stability of reach and road bridge if weir removed<br>• Flood risk impacts associated with any changes in sediment regime is weir removed | • As above | a) H<br>b) M | a) H<br>b) H |
| | 3a<br>Floodplain enhancement | Create small scrapes and ponds for habitat enhancement | SD 7954 2081 | 800m | • Opportunities limited by football pitches and building in close proximity | • Restore some floodplain/offline habitats | L | M/L |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 2 – Edenfield***<br><br>***Section 2.2 pp 6*** | 2a<br>Weir intact (L)<br><br>1e<br>Bank protection– new floodwall options | Remove weir as part of potential FAS here and at Strongstry downstream | SD<br>7923<br>2024 | N/A | • Check flood risk impacts<br>• Carryout a hydraulic modelling to evaluate shoal removal impacts<br>• Ensure no impact on nearby bridge structure<br>• Complete in conjunction with setback floodwalls or enhanced bio-engineering solutions | • Improved conveyance/ connectivity through reach<br>• The formation of natural channel features<br>• Increased riparian options with set back or bio-engineered walls<br>• Reduction in sediment management<br>• Removal of backwater impact<br>• Fish passage improvement | M | M |
| | 2a<br>Weir intact (L) | Remove weir as part of potential FAS here and at Strongstry downstream | SD<br>7902<br>1997 | N/A | • As above | • As above | M | M |
| | 3a<br>Floodplain enhancement | Remove spoil heaps and re-profile banks to increase connectivity with the floodplain. | SD<br>7901<br>1916 | 800m | • FAS feasibility and modelling in conjunction with opportunities to remove weirs, reduce maintenance and set-back or improve bank protection for habitat gain. | • Floodplain habitat heterogeneity increased<br>• Improved flood risk options<br>• Reduced river maintenance<br>• Improved in-channel habitats<br>• Reduction in nutrients to watercourse | H | H |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 3 – Ramsbottom***<br><br>***Section 2.3 pp 9*** | 1c<br>Bank protection - collapsing walls | Remove bank protection or allow natural river processes to continue to degrade walled section | SD 7916 1874 | 750m | • Discuss options with land owner in terms of setting back fencing where necessary<br>• Plant trees and shrubs | • Improved in-channel and bank river processes<br>• Improved riparian habitat | H | M/L |
| | 1b<br>Bank protection – sheet piling | Remove sheet piling and introduce an bioengineered bank protection alternative when redeveloped | SD 7937 1810 | 50m | • Draw up new designs and ensure future development incorporates some space for new bank project solution | • Improved bank habitat | L (very localised) | M |
| | 3a<br>Floodplain enhancement | Create small scrapes and ponds for habitat enhancement<br><br>Reduce/cease dredging | SD 7938 1799 | 600m | • Modelling required to demonstrate the impact of reduced dredging at this site - extent beyond site downstream | • Floodplain habitat heterogeneity increased<br>•<br><br>• Reduced river maintenance<br>• Improved in-channel habitats | H/M | M |
| | 6a<br>Culvert – removal | Remove makeshift culvert | SD 7942 1756 | 5m | • Discuss with landowner – better options | • Improve flow dynamics locally | L | L |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 4 – Summerseat***<br><br>***Section 2.4 pp 10*** | 1c<br>Bank protection - collapsing walls | Remove bank protection or allow natural river processes to continue to degrade walled section | SD 7943 1646 | 1700m | • Monitor changes ( fixed point photography) to ensure no negative impact on railway structure | • Improved in-channel and bank river processes<br>• Improved riparian habitat | M | L/M<br>(M if physically removed) |
| | 2a<br>Weir intact L? | Remove weir or consider introduction of appropriately designed rock ramp if necessary ( see main questions to be addressed) | SD 7914 1638 | N/A | • Check flood risk impacts<br>• Assess why weir introduced<br>• Ensure no impact on nearby railway bridge | • Improved conveyance/ connectivity through reach<br>• The formation of natural channel features<br>• Fish passage improvement | L | M<br>M/H if rock ramp necessary |
| | 3a<br>Floodplain enhancement<br><br>Floodplain storage | Increase floodplain heterogeneity | SD 7914 1638 | 400m | • Flood risk benefit for park infrastructure maintenance<br>• Check impact upstream | • Floodplain habitat heterogeneity | H | H |
| | 4a<br>Riparian vegetation - invasives | Remove | SD 7943 1646 | 1700m | • Needs to be part of a wider catchment approach to eradication | • Allow spread of native vegetation | M | H |
| | 5b<br>Dredging – reduce/stop | Stop dredging of gravel shoals | SD 7932 1510 | 1050m | • Modelling required to demonstrate the impact of reduced dredging at this site - extent beyond site upstream and downstream<br>• Evaluate the impact of the bridges<br>• Complete in conjunction with work at Holcome Brook | • Improve habitat features<br>• Reduce maintenance<br>• Improve fluvial processes | H | M |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 5 – Bury***<br><br>***Section 2.5 pp 13*** | 4a<br>Riparian vegetation - limited | a) Plant native trees and shrubs<br>b) Fence –off section away from bank and allow natural vegetation recovery. | SD 7954 1399 | 1350m | • Agreement with landowner and farmer for either option | • Both options will improve bank-side biodiversity.<br>• Provide some fish cover | M | M/L |
| | 2a<br>Weir – intact (H) | a) Add fish ladder to weir<br>b) Use canal feeder stream to improve fish passage | SD 7866 1308 | N/A | • Option B:<br>• Model and evaluate implications related to changes in flow splits<br>• Establish if fish would use this bypass channel | • Improve fish passage. Note: option B) is likely to beneficial for a wider species range. | H | H |
| ***Map 6 – Kirklees 1***<br><br>***Section 2.6.1 pp 14*** | 5a<br>Bed protection – intact concrete<br><br>1a<br>Bank protection – intact concrete | a) Remove concrete bed<br>b) Re-grade bank<br>c) Consider installing small low flow deflectors to improve habitat | SD 7899 1193 | 350m | • Ensure there is no adverse impact in terms of unacceptable head cutting upstream<br>• Ensure new backs are set back or old ones are structurally sound | • Habitat gain for a range of species<br>• Aesthetical improvement<br>• Improved fluvial processes through reach | M | H |
| | 5a<br>Concrete bed – intact concrete | a) Remove concrete bed<br>b) Hide concrete bank and re-grade left hand bank to retain capacity | SD 7977 1122 | 150m | • Ensure channel capacity is not reduced | • Habitat gain along bank<br>• Improved aesthetics | M/L | M/H |
| | 2a<br>Weir(s) intact (L) | Remove | SD 7901 1192<br><br>SD 7966 1137 | N/A | • Ensure no water resources issue<br>• Ensure no flood risk issue<br>• Ensure no sediment movement (contamination ) | • Improved fish pass | M | M/L |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Map 6 – Irwell***<br><br>***Section 2.6.2 pp 17*** | 2b<br>Weir collapsing (M) | a) Remove part of weir and ensure structural stability of remainder<br>b) Replace with rock ramp | SD 8000 1139 | N/A | • A)Evaluate risk in terms of potential head cutting<br>• B) Ensure design to not affect channel capacity. | • Improve fish passage<br>• Improve aesthetics (especially B). | A) H<br>B) M/H | M |
| | 7<br>Unnatural banks, bed, and planform | Set back new development to provide a riparian corridor<br><br>Improve longitudinal continuity | SD 8016 1168 | 1600m | • Ensure flood risk is not adversely affected; any work will require detailed modelling<br>• Consider benefit for wildlife and local community<br>• REFER to the London Rivers Action Plan | • Improve fish pass<br>• Improve natural morphological features<br>• Improve flow dynamics<br>• Provide space for the river and reduce maintenance requirements<br>• Improve aesthetics<br>• Improve community connectivity to the floodplain | H | H ?<br>(but should be part of the wider improvement for Bury) |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Kirklees 2***<br><br>***Section 2.7 pp 18*** | 1b<br>Bank protection – intact sheet piling | Remove sheet piled banks if there is an opportunity to redevelop this section | SD 7748 1382 | 350m | • Cannot be removed currently but should be considered if development opportunities or change of land use/owner in the future. | • Improvement aesthetically<br>• Improved bank habitat | M/L | M/H |
| | 6a<br>Culvert -intact | De-culvert if opportunity arises | SD 7772 1362 | 80m | • Can't be removed currently but should be considered is redevelopment of site | • Improved aesthetically<br>• Opening up a section of water course is beneficial for increased habitats | M | L |
| | 2b<br>Weirs – collapsing (H) | Remove and replace with step weirs and pools to improve fish passage | SD 7803 1356 | 50m | • Ensure integrity of reservoir in not negatively affected | • Improved fish passage<br>• Ensure whole section of this modified section is not undermined | M/H | M/H |
| | 6b<br>Culvert - collapsing | Remove remnants of culvert | SD 7804 1364 | 50m | • Evaluate soil condition<br>• Evaluate soil contamination<br>• Flood risk modelling<br>• Detailed design of new watercourse dimensions and planform. | • Improved aesthetically<br>• Opening up a section of water course is beneficial for increased habitats<br>• Improved conveyance of water and sediment | M/H | L/M |
| | 2b<br>Weir – collapsing (L) | Remove collapsed debris to help fish passage.<br><br>If necessary make good remainder of weir or leave to degrade | SD 7826 1312 | N/A | • Makes checks from time to time regarding changes upstream in planform as a result of collapsed section of weir. | • Improved fish passage<br>• Improved sediment connectivity downstream<br>• Improved flow and morphological conditions | M | L |
| | 1d<br>Bank protection – failing gabion baskets | Replace gabions with a semi-natural bank projection solutions | SD 7877 1241 | 60m | • Check that bank protection is necessary at this location ( assume to protect feeder stream and reservoirs) | • Improved bank habitat | L | M/L – note: implement only if necessary |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Kirklees 3***<br><br>***Section 2.8 pp 22*** | 3a<br>Floodplain enhancement | Create mosaic of wetland, rush-type pastureland and improve tree cover long water course | SD 7598 1457 | 950m | • Agreement with land owner to achieve options | • Large scale floodplain heterogeneity improvement for a range of species | H | L/M |
| | 6a<br>Culvert - intact | De-culvert as much as possible | SD 7652 1409 | 60m | • Agreement with land owner to achieve options | • Reduce future maintenance in terms of any collapse or sediment<br>• Reduce probability of flooding of cottages | L/M | M |
| | 2b<br>Weir – collapsing (L) | Remove weir or notch | SD 7708 1394 | N/A | • Agreement with land owner to achieve options<br>• Check impact on small informal crossing upstream or ideally move this | • Fish passage improved in an otherwise naturally improving section | M | L |
| ***Irwell 7 – Bury***<br><br>***Section 2.9 pp 23*** | 7<br>Wide scale urban redevelopment<br><br>Weirs collapsing and intact ( H) | Look for a range of opportunities to improve fish passage throughout this whole section.<br>Note: At Buckley Wells a fish bypass may be one option | SD 8013 1166 | 1500m | • Impact on flood risk and changes to flow and morphology<br>• Will need to modelled | • Great improvement in fish passage<br>• Improvement of flow and morphological dynamics<br>• Improved heterogeneity of habitats in-channel | H | H |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 8 – North Radcliffe***<br><br>***Section 2.10 pp 24*** | 2b<br>Weir – collapsing ( L) | Remove remainder of weir or allow to continue to disintegrate naturally | SD 7941 0907 | N/A | • None | • Improve morphological continuity locally | L | L/none |
| | 2a<br>Weir - intact | Create by pass channel using Bealey's Goit channel . Note: fish ladder or removal unlikely to be options here but in context of wider development in the area should still be considered. | SD 7962 0904 | N/A | • Impact on flow split if bypass channel used<br>• Impacts on flows and flood risk if bypass options considered<br>• Impact on fish passage if possible hydro-power scheme at this location agreed | • Major improvement to fish passage and or morphological and hydrological diversity depending on which option agreed upon. | H | H |
| | 5b<br>Dredging – reduce/stop | Stop dredging of gravel shoals | SD 7998 0895 | 40m | • Modelling required to demonstrate the impact of reduced dredging at this site - extent beyond site upstream and downstream<br>• Evaluate maintenance of river here in relation to any work completed at weir upstream | • Improve habitat features<br>• Reduce maintenance<br>• Improve fluvial processes<br>• | H | M, in terms of modelling |
| | 3a<br>Riparian - enhancement | Enhancement though moving back flood banks and incorporating backwater areas etc designed to flood during high flow events. | SD 8026 0842 | 950m | • Ensure that the proposed designs at this site take account of the river processes – currently a 2 stage channel with little account of in-channel processes – see text in section 2.9 | • Improved riparian features that are lacking along much of the Irwell corridor<br>• Improved flood risk benefit | M/H | H |
| ***Irwell 9 – Radcliffe***<br><br>***Section 2.11 pp 26*** | 4b<br>Riparian vegetation - invasives | Look for opportunities to eradicate | SD 8009 0772 | 2000m | | • Opportunity to support more diverse natural riparian habitats | M | H |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 10 – L. Lever***<br><br>***Section 2.12 pp 26*** | 2a<br>Weir - intact | Remove, consider option for fish by pass or if necessary install fish ladder | SD 7680 0656 | N/A | • Evaluate this weir in conjunction with this whole reach and opportunities to improve fish passage and river morphological dynamics<br>• If weir removed then would need to consider contamination issues and complete in conjunction with wider river restoration needs upstream to support banks in the shorter term.<br>• Impact of any split flows if bypass considered | • Major fish passage improvements<br>• Major hydromorphological benefit (if weir removed) | H (if considered in conjunction with other weir in this section and section 10) | H |
| | 2a<br>Weir - intact | Remove or install fish ladder | SD 7643 0345 | N/A | • Evaluate this weir in conjunction with this whole reach and opportunities to improve fish passage and river morphological dynamics<br>• If weir removed then would need to consider contamination issues and complete in conjunction with wider river restoration needs upstream to support banks in the shorter term. | • Major fish passage improvements<br>• Major hydromorphological benefit ( if weir removed) | H (if considered in conjunction with other weir in this section and section 10) | H |
| ***Irwell 11 – Kearsley***<br><br>***Section 2.13 pp 27*** | 2a<br>Weir – intact (H) | Remove, or install fish ladder | SD 7590 0646 | N/A | • Evaluate this weir in conjunction with this whole reach and opportunities to improve fish passage and river morphological dynamics<br>• If weir removed then would need to consider contamination issues and complete in conjunction with wider river restoration needs upstream to support banks in the shorter term. | • Major fish passage improvements<br>• Major hydromorphological benefit ( if weir removed) | H (if considered in conjunction with other weir in this section and section 10) | H |
| | 2a<br>Weir – intact (H) | Remove, or install fish ladder | SD 7504 0567 | N/A | • As above but not that this weir is close to the railway line | • As above | As above | As above |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 12 – Ringley***<br><br>***Section 2.14 pp 28*** | 2a<br>Weir – intact (H) | Remove, or install fish ladder | SD<br>7643<br>0482 | N/A | • Evaluate this weir in conjunction with this whole reach and opportunities to improve fish passage and river morphological dynamics<br>• If weir removed then would need to consider contamination issues and complete in conjunction with wider river restoration needs upstream to support banks in the shorter term. | • Major fish passage improvements<br>• Major hydromorphological benefit ( if weir removed) | H (if considered in conjunction with other weir in this section and section 10) | H |
| ***Irwell 13 – Clifton***<br><br>***Section 2.15 pp 28*** | Aqueduct | Consider removal if opportunity arises | SD<br>7909<br>0345 | N/A | | | L | H |
| ***Irwell 14 – Clifton*** | NO SPECIFIC RECOMMENDATIONS | | | | | | | |
| ***Irwell 15 – Clifton***<br><br>***Section 2.17 pp 29*** | 4a<br>Riparian-enhancement | Create small wetland area | SD<br>8177<br>0116 | 150m | • Engagement of local community to ensure this area is not earmarked for other purposes and encourage interest and ownership of such a project | • Encourage local community engagement<br>• Provide small riparian habitat which is lacking from much of this watercourse | L | L |
| | 3a<br>Floodplain enhancement<br><br>3b<br>Floodplain storage | Create scrapes, wet woodland areas, and mixed habitat features associated with floodplain areas<br><br>Improve connection between the river and the floodplain area | SD<br>8183<br>0063 | 2400m | • Requires modelling for demonstration of flood risk benefit<br>• Engage with local community with respect to amenity needs | • Option to store water to improve flood storage<br>• Improve connectivity between the floodplain and river<br>• Increase floodplain habitat heterogeneity<br>• Improve floodplain processes | H | H |
| | 2a<br>Weir – intact (M) | Remove weir or if not feasible create a notch to improve fish passage | SD<br>8145<br>0046 | N/A | • It there any impact on flow conveyance under the bridge downstream if the weir was removed.<br>• Establish the impact on the banks upstream if the weir was removed | • Improve fish passage<br>• If weir removed improve connectivity of fluvial process and flow dynamics | M | M |

| Report map and section reference | Issue<br>If a weir, fish obstruction is noted in terms of H, M, L | Options | Upstream NGR | Approx Length | Main questions to be addressed | Main Benefits | Ecological Benefit (H,M,L) | Cost (H,M,L) |
|---|---|---|---|---|---|---|---|---|
| ***Irwell 16 – Salford*** | 2a<br>Weir – intact (H) | Cascade<br>Fish ladder | SD<br>8244<br>9876 | N/A | • Evaluate the impact of local infrastructure on any changes made to this weir | • Improve fish passage | M | H |
| ***Section 2.18 pp 30*** | 7<br>Wide scale urban redevelopment | Set back defences as far as possible<br><br>Look for opportunities to remove sheet piling and introduce bio-engineering | SD<br>8218<br>9979 | 3000m | • Take account of flood risk aspects | • Allow space for natural fluvial processes in-channel<br>• Improve the riparian corridor<br>• Improve bank habitats<br>• Reduce maintenance<br>• | H | H |

# 5 Conclusions and Recommendations

Both the River Irwell and the Kirklees Brook have a long history of modification, dating back to the industrial revolution, including floodwalls, culverting, widening, dredging, straightening, and the construction of weirs. These modifications are particularly apparent in the urban reaches of the river, where housing and industry are often located close to the river banks and, whilst this will limit the possibilities for improvement in some locations, there is, nonetheless, strong visual evidence of natural recovery in many places along the Irwell. In many places, this has been as a result of changes in land use, as milling and mining industries have declined and been superseded by agriculture. Where weirs have collapsed, there has been significant local recovery, especially in terms of morphological processes, often with a series of riffle features forming downstream. For a Candidate Heavily Modified watercourse, these rivers are showing strong signs of recovery of morphological and biological elements, and indeed in many locations (though not all), water quality is surprisingly good, given the industrial legacy.

Specific recommendations and maps for individual river sections can be found in sections 2 and 4 of this report. There are a number of common themes along the river which are in broad agreement with those included for the Irwell in the draft River Basin Management Plan for the North West area. These include the following:

- ***Setting back and re-profiling banks:*** There are opportunities for small-scale enhancements of the river bank and surrounding areas along the length of the river, but particularly within more urban areas. This could include setting back and re-profiling the banks where steep flood banks are present, to produce a more natural riparian habitat, perhaps creating a wetland area at some locations. This will improve both the aesthetic and habitat quality of the river corridor.

- ***Linking floodplain storage and habitat enhancement:*** Even greater opportunities exist where sections of the river are coincidental with large urban regeneration schemes. Given climate change concerns, leaving space for the river and its floodplain area to semi-naturalise should become an even stronger recommendation and, indeed, a necessity. Linking floodplain storage and enhancement has been identified in a number of locations.

- ***Fish and hydro-morphological longitudinal connectivity*****:** Improvement of fish passage and hydro-geomorphological processes are probably key elements that need to be addressed along the Kirklees and Irwell Rivers. Removal or bypass of weirs has been noted in many locations. Often, the original requirement for these weirs (e.g. to harness water for mill wheels) has long since declined and many are at the end of their structural life, especially in the reaches covered by Maps 10 and 11. It is recommended that removal, or improvement of fish passage either through the introduction of cascades, bypass channels, notches or fish ladders, should be consider in a strategic fashion. Wherever there may be an opportunity to remove a weir, this should be considered as a first option, and fish ladders fitted retrospectively, a last solution.

- ***Culvert and concrete-faced bed and bank removal:*** Culverts and concrete bed and bank removal options have been highlighted in places. Some of these will probably only be feasible in the context of redevelopment, but should be considered as an option wherever practicable, since removal would benefit

wildlife habitat, visual amenity and, with appropriate design, improve flood risk concerns and reduce the need for future maintenance.

- ***Vegetation planting:*** Planting some of the bare, open lengths of bank with appropriate native trees and other vegetation would improve habitat quality and diversity along the river corridor.

- ***Wider floodplain habitat heterogeneity:*** Some areas (especially some of the more rural areas) can be enhanced to achieve much wider habitat gain, through the construction of permanent and semi-permanent ponds and scrapes, and wet woodland.

- ***Fencing:*** In rural areas (especially the upstream sections) animal poaching is a problem. The introduction of fencing would be beneficial but must be set back from the bank. Some managed poaching should be allowed, to ensure that a mix of vegetation forms, rather than a uniform blanket of invasive species or nettles.

- ***Invasive species control:*** Invasive non-native species such as Japanese Knotweed, Giant Hogweed and Himalayan Balsam are all common along the river course and should be eradicated where possible. It is recognised that this is a difficult task, but it has been tackled in some smaller areas. Again, development/regeneration areas provide one opportunity for tackling this problem effectively.

- ***Bio-engineering, where bank protection necessary:*** In some cases, current hard bank protection (walls and sheet piling) is beginning to fail. In many places, there is little reason to retain these old bank revetments, since they are a legacy of historical, now redundant, mill systems. However, it is recognised that in some instances (especially where close to major infrastructure or housing), holding the banks in place will be necessary. A series of alternatives have been suggested that can form a more 'natural' bank edge. **Any restoration measures suggested in this report must undergo design that is appropriate for this river system, and examples are provided only to demonstrate overall guiding principles.**

- ***Sediment management:*** Dredging and sediment management has also been recognised as an issue here, in the Gravel Management Plan and the Lower Irwell Fluvial Audit. In many cases, though certainly not all, there are specific reasons why sediment is accumulating in particular locations (e.g. related to a weir upstream or over-widening of sections associated with bridge construction). Frequently, however, it is questionable whether the current sediment management regime is necessary, especially where it will clearly have a negative impact on riverine habitats. It is recommended that some modelling is undertaken to establish the true impact of some of these shoals in terms of flood risk impact.

Overall, there a strong case, along these two rivers, for improving lateral and longitudinal connectivity which should, bring about benefits for people and wildlife through the restoration of some natural fluvial processes.

The suggestions highlighted in this report are not necessarily quick-fix, cheap options, and clearly there will be a need to look for external funding of options. Whilst European funding may be required, the DEFRA River Restoration Fund may be one

option for allowing for a strategic Irwell enhancement strategy to be implemented, and opportunities through this mechanism should be investigated.

## Advisory note

This report outlines options that the Environment Agency and others may wish to consider for the River Irwell. These notes are compiled on the basis of RRC's extensive expertise and a short walk over site visit of the river. RRC seeks to provide advice and suggestions to facilitate river restoration progress, but is careful not to produce detailed design drawings etc. In this way, the Centre limits its liability. Liability for any options should be with the consultants tasked with the detailed work and technical feasibility study if necessary.

# References

Babtie, Brown and Root (2004). Upper Irwell Fluvial Audit. Commissioned by the Environment Agency.

Jacobs Babtie (2006). Upper Irwell Gravel Management Plan. Commissioned by the Environment Agency.

Environment Agency (2008). River Irwell Catchment Flood Management Plan. Final Report 2008.

Environment Agency (2008). Draft River Basin Management Plan, North West River Basin District.

NEED to add other references – web based

Bury Town Centre is coming up for re-development (http://www.bury.gov.uk/Business/EconomicDevelopment/EconomicRegeneration/BuryButBetterMasterPlan/default.htm ) which includes a large stretch of the River Irwell corridor

Radcliffe (http://www.dumerslane.com/downloads/technical_details/Nolan%20Redshaw%20Ltd/Supporting%20Statement.pdf).

Lower Broughton redevelopment (http://www.salford.gov.uk/living/housing/marketrenewal/broughton-regeneration/lowerbroughton.htm)

Irwell City Park proposal http://www.salford.gov.uk/living/regeneration/irwellcitypark.htm ,

# Appendix A – Section Maps

# Appendix B – Photographs

*Files on accompanying DVD*

# Appendix C – Cedar Creek case study

Removal of a large (6m high) dam on Cedar Creek, in Washington State. The project involved extensive dewatering (bypassing the dam and its backwater), removal of over 15 000 $m^3$ of sediment, and bank protection to prevent excessive erosion as the new channel adjusted, upstream. See captions for further details. All photos courtesy of Bill Norris, Inter-Fluve Inc.

**Figure 10: 6m dam in place, before works**

**Figure 11: Sediment removal operation, with diversion pump line visible**

**Figure 12: Coir matting bank protection (later planted out with native species), with coarse woody debris added to dissipate energy and increase flow diversity**

**Figure 13: Cedar Creek starting to naturalize after first winter. High flows have redistributed bed material and woody debris**